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OCTOBER, 1900

SERIES II. Publications of the University of Cincinnati VOL. I.

Morphology of the Myxinoidei

I. Skeleton and Musculature

BY

HOWARD AYERS AND C. M. JACKSON

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MORPHOLOGY OF THE MYXINOIDEI.

I. *SKELETON AND MUSCULATURE.*[1]

HOWARD AYERS AND C. M. JACKSON.

CONTENTS.

INTRODUCTION.

IT is now sixty-four years since Johannes Müller published the first part of his "Anatomie der Myxinoiden." Since that time almost nothing has been added to our knowledge of the anatomy of these interesting and important forms of ancestral

[1] Contributions from the Morphological Laboratory of the University of Cincinnati.

vertebrates. Not a few papers have dealt with the comparative anatomy of the myxinoid fishes; but the authors of these papers, almost without exception, have drawn their anatomical knowledge from Müller's monograph, instead of going to nature for facts, the assumption being that Müller saw everything worth knowing and saw it right. As illustrating the condition of our knowledge of myxinoid anatomy at the present time we shall cite the statements with reference to these animals in Parker and Haswell's *Text-Book of Zoölogy*, which is perhaps the most excellent zoölogical text-book in any language up to date.

On page 115, under the head of the "Distinctive Characters of the Craniata," it is stated that "the pharynx is of moderate dimensions and is perforated by not more than seven pairs of gills." In 1894 Dr. Ayers called attention to the general neglect, of which this is an example, of the fact that Bdellostoma dombeyi has from 6 to 14 pairs of gills, and that consequently in any statement of the general characters of the Craniata such an important and evidently ancestral character must be given prominent notice. Instead of this it has been generally ignored.

In the same paragraph it is stated that there are at least ten pairs of cranial nerves, whereas in Bdellostoma we can show that there is no trace of the three eye-muscle nerves. In the description of "Class I — Cyclostomata" it is stated that these animals are "distinguished from all other Craniata by the possession of a suctorial mouth devoid of functional jaws, by a single olfactory organ." In 1890 Dr. Ayers proved conclusively that the Petromyzontes had a *pair* of nasal organs, and again, in 1894, that the myxinoids were no exception to the general rule among the Craniata, since Bdellostoma and Myxine possess a paired nasal organ. Dr. Ayers also showed conclusively that the myxinoid mouth is not *suctorial* but *raptorial.*

With reference to the absence of functional jaws, we refer to the following pages and plates, in which we believe we have demonstrated that in these fishes the lower jaw is present and functional, while the upper jaw is rudimentary and fused with the cranial cartilages. With reference to the inaccuracies and

omissions contained in Müller's and all subsequent descriptions of the cranial skeleton, we refer to the account which we give in the following pages.

On page 120 our authors write: "The whole branchial basket lies external to the gill pouches and branchial arteries, not, like typical visceral arches, in the walls of the pharynx." We are now prepared to show that the skeleton of the branchial apparatus in myxinoids occupies both positions, and that no such morphological distinction can be made between the internal and external branchial apparatus of the cyclostome fishes.

On page 128, under head of distinctive characters of the Cyclostomata, Parker and Haswell repeat some of the statements already noted and add the following: "The Cyclostomata are Craniata in which the mouth lies at the bottom of a sucker-like buccal funnel, and 'has no jaws.' A buccal funnel is present only in the Petromyzontes, for in the Myxinoids the mouth is terminal.

"Horny teeth are borne on the interior of the buccal funnel and on the large tongue." This statement is true, as regards the buccal funnel, only of the Petromyzontes, since the funnel is entirely wanting in the myxinoids. The statement that the teeth are also borne on the tongue brings us to a very interesting psychological phenomenon.

Ever since Johannes Müller described the so-called tongue of Bdellostoma, every writer on myxinoid anatomy, as well as every anatomist who has personally studied the anatomy of these forms, has accepted without question or modification this homology, based solely on the authority of the eminent German anatomist. Yet, strange to say, among all other fishes a tongue is held to be absent, and, stranger still, Müller's own account of the organ effectually disproves the homology he sought to establish. For a further consideration of this structure we refer to the body of this paper.

On page 128 they say that "there is no exoskeleton." This statement must certainly be modified, for the teeth are true exoskeletal structures.

In Bdellostoma the adult kidney is certainly sometimes both Pronephros and Mesonephros, not simply Mesonephros.

Parker and Haswell's statement that the genital products make their exit by the genital pores is not true of the myxinoids, for their eggs and spermatozoa both leave the body through the ***abdominal pore.***

On page 129 it is stated that "the slime glands of Myxine contain peculiar thread cells, containing a much coiled thread which unwinds either before or after the discharge of the cells from the gland."

Under normal conditions the thread cell never unwinds until it is extruded from the glands; for its unwinding is due to the absorption of water by the thread and is a hygroscopic function entirely. The thread filament constitutes almost the entire mass of the oval spool.

The statement that "the branchial basket in the myxinoids is reduced to a vestige," that "it is quite rudimentary, being represented in Bdellostoma only by a small, irregular cartilage in the walls of the oesophago-cutaneous duct, and in Myxine by a smaller cartilage on the right side supporting the common external gill tube," is, as we shall see further on, due to the failure of Müller and subsequent anatomists to find the major part of the branchial skeleton. Every gill in Bdellostoma is provided with a branchial cartilage.

On page 130 the statement that "the neural canal is overarched merely by fibrous tissue; there is no trace even of the rudimentary neural arches of the lamprey," is far from the truth, since we have discovered that Bdellostoma possesses a true neural arch as a part of its axial skeleton.

As regards Johannes Müller's descriptions of the muscles of Bdellostoma, we find them inadequate in many cases, since he failed to carefully trace out the forms of the muscles; and in other cases he failed to see the true homologies, and thus necessitated the changing of several names.

The erroneous statements in myxinoid anatomy which we have pointed out above are certainly sufficient to render necessary a careful reëxamination of the whole subject, and upon such a work Dr. Ayers has been engaged since 1892.

During the past year Mr. C. M. Jackson has taken part in a final review and careful redissection of Bdellostoma, with

partial dissections of Myxine and Petromyzon, and the results which we conjointly publish are vouched for alike by both of us. Mr. Jackson has made a complete, extremely careful, and independent study of the myxinoid skeleton, and Dr. Ayers has likewise restudied the musculature. We have checked each other's work on the skeleton, and while we do not presume to have exhausted the subject, we think we have not overlooked any very important anatomical details. The following papers on myxinoid anatomy are now ready for the press:

"On the Morphology of the Eye of Bdellostoma dombeyi."

"Ovigenesis in Myxinoids."

"On the Structure of the Slime Glands and Skin of Bdellostoma dombeyi."

Preservation of Material.

The Bdellostoma material used in the present investigation was killed and hardened in 10% formalin, and preserved partly in alcohol and partly in formalin, as well as in the following mixture of the two: 95% alcohol, 6 parts; 2% formalin, 4 parts. The formalin has been found to be exceedingly valuable in preserving specimens for study of the cartilaginous skeleton. The effect of formalin is to give the cartilage a pink or reddish tinge, which gives an excellent differentiation and brings out many points of structural detail which might be overlooked in alcoholic material. Occasionally, however, non-cartilaginous connective tissue takes on the same tinge, so that in all doubtful cases a histological examination is necessary. In all other respects as well, the formalin material is far superior to alcoholic material.

The Skeleton of Bdellostoma.

The skeleton includes all those condensations of the mesoderm which are specially developed to support or protect the softer tissues of the body. The skeletal parts which are within the body make up the endoskeleton, while those in the external integument constitute the exoskeleton. In the latter case the mesoderm enters into intimate relations to ectodermic structures.

Endoskeleton.

The endoskeleton, excepting the notochord, is mainly membranous. Here and there it is reinforced by cartilaginous rods, bars, rings, and plates, which lie within the membranous skeleton, and may be regarded simply as chondrifications along certain lines of stress. No bone or calcified tissue of any kind is present anywhere in the skeleton.

The *notochord* (Pl. XXII, Figs. 1, 2, 4–6; Pl. XXIII, Fig. 14, *nt*) is an elastic cylindrical rod extending nearly the entire length of the body (14–26 inches). It lies in the median dorsal line, deeply imbedded between the lateral trunk muscles of the right and left sides. Anteriorly it tapers to a point and ends between the parachordal cartilages. Posteriorly its termination lies in a groove upon the dorsal surface of the median ventral cartilage, and its end lies a short distance in front of the posterior end of the spinal cord. The shape of the notochord in cross-section varies somewhat in different regions. Though approximately circular, it is usually somewhat flattened or slightly concave above, where it is in contact with the neural tube. In the extreme anterior region it is laterally compressed and somewhat triangular in cross-section.

The *notochordal tissue* (Pl. XXII, Fig. 3, *nt*) is made up of cells containing very large vacuoles (*vc*) filled with a clear, homogeneous liquid, around which the protoplasm forms an extremely thin layer. The chordal tissue has a honeycomb structure which produces the characteristic reticular appearance seen in sections. The cells are somewhat flattened, with angular walls, and have their long axes placed radially, as shown in Figs. 1 and 2 of Pl. XXII. The nuclei are prominent, and generally found lying in the protoplasmic layer toward the ventral side. In some cases, however, especially toward the outer surface of the notochord, nuclei are found near the center of the cells, and apparently connected with the cell wall by protoplasmic strands. The striking resemblance between chordal tissue and certain vegetable tissues has often been noted.

The central axis of the notochord is marked by a dense white fibrous *central core* (Figs. 1, 2, *fc*) which extends throughout almost its entire length. The form and size vary somewhat in different regions. In the head region the core is triradiate in cross-section (Fig. 1). In the gill region it is flattened dorso-ventrally, while farther back in the body region it becomes more irregular, and relatively much larger. The central core is made up of dense, coarse fibers, closely packed, and running for the most part longitudinally. The fibers run out among, and are continuous with, the walls of the chordal cells. In the extreme anterior region of the notochord, and in some places near the posterior end, the fibrous core fades out and passes gradually into ordinary chordal tissue. The core contains no traces of nerves or blood vessels.

Surrounding, the chordal tissue we find a cellular sheath having the appearance of an epithelial layer (Fig. 3, *ex*). In the anterior notochordal region, where the cells of this sheath are larger and more definitely marked, they form a one-celled layer, the cells being somewhat cubical above the notochord and columnar below. Toward the posterior region the layer becomes two or three cells deep, and the individual cells are smaller and flattened. The nuclei are large, and vacuoles are often found in the ends of the cells lying next to the chordal tissue. This layer is directly connected with the chordal cells, and is not separable as a distinct layer. All stages are found between the solid, undifferentiated cells of the external cellular sheath, and the deep chordal cells within walls enclosing large vacuoles.

The *notochordal sheath* proper (Pl. XXII, Figs. 1–4, *sh*) is a thick, strong investment immediately surrounding the notochord. It is fibrous rather than laminated in structure, at least for the most part. The fibers are chiefly circular in direction, but vary somewhat in different regions. They are usually so closely packed as to give a homogeneous appearance to the sheath. No nuclei, nerves or blood vessels are present. In most places the notochordal sheath seems to be made up of different layers, whose fibers vary somewhat in direction. Three layers may usually be distinguished, especially in the

anterior region (Fig. 3, sh_1, sh_2, sh_3). The fibers of the inner and outer of these three layers have the same general direction, and are usually parallel, while those of the middle layer are often interlaced in the most complex fashion (see Fig. 3, sh_2). The relative and actual thickness of these layers varies considerably in different regions, but the inner layer is always the thinnest. In some places all three layers are fused into one, the boundaries being indistinguishable.

The external boundary of the notochordal sheath is always formed by a thin, dense membrane, which stains deeply. This is the *elastica externa* (Fig. 3, *mle*). Though usually homogeneous in appearance, in some places it shows a distinctly fibrous structure. Whether the *elastica externa* is really a part of the notochordal sheath proper, or a derivative of the surrounding skeletogenous layer, is a matter of doubt. The structure and appearance of the layer indicate the former. It may be remarked that although both the central core and the notochordal sheath are doubtless derived from the chordal tissue (the latter from the cellular sheath), it is evident that neither is a *cuticular* product, in the ordinary sense of the term, although it is always so described.

An interesting histological variation is found in the anterior region, where the notochord lies imbedded between the parachordal cartilages. The *elastica externa*, which separates the notochord from the surrounding cartilage, becomes irregular in outline, and the different sheath layers fuse into one. The cellular sheath of the chordal tissue becomes irregular, while the chordal tissue itself is very gradually replaced by *cartilaginous* tissue. Thus near the anterior end of the notochord we find *the space inside the notochordal sheath entirely filled by cartilage* (Fig. 4, *nt*) Just behind the tip of the notochord, which projects in the median line in front of the parachordal cartilages (Pl. XXIII, Fig. 7), the notochordal sheath disappears, and we find that the tip of the notochord is a conical *cartilaginous structure*, surrounded only by the skeletogenous layer. The cartilage replacing the chordal tissue has an appearance somewhat different from that of the surrounding parts. Near the posterior end of the notochord we find in places a similar

development of *cartilage within the notochord,* but not so marked as in the anterior region.

The *skeletogenous layer* (Plate XXII, Figs. 1–4, *sk*) lies immediately external to the *elastica externa.* It surrounds the notochord, and above, on each side, it divides. One layer continues in contact with the *elastica externa,* the other rises and arches to form the *neural tube.* This tube forms a continuous semicylindrical canal just above the notochord, with lateral foramina for the exit of the spinal nerves. Within this neural tube there is also a fibrous layer closely investing the spinal cord (*sp*) and another which covers the so-called "fatty tissue" (*F*) which more or less completely fills the dorsal part of the tube. The skeletogenous layer is composed of strong fibrous connective tissue, well supplied with blood vessels and nerves. It is directly continuous with the intermuscular septa, as shown in Figs. 1 and 2, *ims.* Above, it is continuous with the median septum, separating the myotomes of the right and left halves of the body (*mds*). Below, on each side, it is continuous with the *fascia superficialis interna,* which surrounds and supports the body cavity. In the skeletogenous layer, especially near the inferior lateral angles of the neural tube, we occasionally find incipient patches of cartilage which are interesting as the first traces of the cartilaginous structures more fully developed in the head and tail region.

Skeleton of the Head Region.

(Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7.)

The skull, as a whole, may be described as forming two tubes, a smaller dorsal and a larger ventral. The smaller dorsal tube includes the cranium, posteriorly, and the nasal tube, anteriorly. The larger ventral tube is composed of a framework of cartilages surrounding the mouth and pharynx. The mouth is surrounded by a system of cartilages supporting the tentacles. For some distance behind the mouth the side walls of the ventral tube are unsupported by cartilage, but posteriorly the tube is surrounded by the complicated framework

of cartilages known as the "pharyngeal basket"; while in the gill region the series of small gill bars represents the remarkable "branchial basket" of Petromyzon.

The membranous cranium (Pl. XXII, Figs. 4–6, *cr*) is a direct continuation of the skeletogenous layer surrounding the spinal cord (*cf.* Figs. 1 and 4). The "fatty tissue" is also continued into the cranial cavity as a thick layer of loosely interwoven elastic fibers (*F'*). The cranium is somewhat flattened dorso-ventrally.

The anterior wall has a median dorso-ventral ridge which projects backward between the olfactory lobes of the brain. The floor is concave within, both laterally and longitudinally. The roof projects upward in a median longitudinal septum (Fig. 4, *mds*) between the myotomes of the right and left halves of the body. The cranium is perforated laterally for the exit of all the cranial nerves, except the olfactory, which perforate the anterior wall. The cranial walls have no cartilaginous support, excepting the floor, which is supported by the parachordal cartilages and the trabeculae.

The parachordal cartilages (Pl. XXII, Fig. 4; Pl. XXIII, Fig. 7, *pc*) are a pair of cartilages which support the posterior portion of the cranial floor (*os basilare* of J. Müller). The parachordals are composed chiefly of a pair of roughly prismatic cartilaginous bars lying in the skeletogenous layer of the membranous cranium. The posterior halves of the parachordals are situated one on each side of the notochord. They are nearly parallel, converging slightly toward the median line, from behind forward. The anterior halves of the parachordals diverge, and extend antero-laterad to fuse with the posterior ends of the trabeculae. The diverging anterior halves of the parachordal bars form the posterior boundary of the large hypophysial fontanelle (see Fig. 7). In the angle formed by these diverging bars the cartilaginous anterior tip of the notochord projects in the median line, as previously noted. In the posterior region the parachordal cartilages fuse together in the median line under the notochord, so that the latter appears to lie in an open groove, as shown in cross-section in Fig. 4. In some places, however, the parachordal cartilages fuse together both above

and below the notochord, forming a complete cartilaginous sheath. The form and extent of this sheath varies considerably in different specimens.

The parachordal cartilage on each side is expanded laterally into a thin sheet of cartilage forming the *auditory capsule* (Pl. XXII, Fig. 4; Pl. XXIII, Fig. 7 *A*). These capsules are two somewhat kidney-shaped structures, with their long axes lying parallel to the parachordals. Their shape in cross-section is shown in Fig. 4. The ventral walls are continuous with the inferior external angles of the parachordals. In the anterior and posterior regions of the capsules the dorsal walls are continuous similarly with the superior external angles of the parachordals; in the middle region, however, the dorsal walls of the capsules are separated from the parachordals by the auditory foramina (Pl. XXII, Fig. 4; Pl. XXIII, Fig. 7, *f*). These are two large elliptical foramina extending the greater part of the length of the auditory capsule. The foramina are closed by the membranous cranial wall, which is perforated by small openings for the exit of the auditory nerves. The posterior third of the auditory capsules is continuous, externally, with the upper ends of the hyoid arches. Anteriorly the walls of the auditory capsules, together with the anterior ends of the parachordals, are fused with the posterior ends of the trabeculae.

The *trabeculae* (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7, *Tr.*, *tr*) are a pair of latero-inferior bars which form a frame for the support for the anterior half of the membranous cranium. Posteriorly they are comparatively thick and strong. At their posterior ends they have three attachments: (1) an internal, with the anterior ends of the parachordal cartilages; (2) a median, with the anterior wall of the auditory capsule; and (3) an external, with the posterior process from the pterygo-quadrate cartilage. Anteriorly, a short distance behind the anterior end of the membranous cranium, the anterior horns of the trabeculae extend downward, forward, and inward, as slender bars (*tr*) which merge into the median hypophysial plate. At the point of junction of the anterior horn (*tr*) with the main bar of the trabecula (*Tr*) there is given off externally,

on each side, a short, thick lateral process which connects the trabecula with the palatine bar (*Pl*). The space enclosed by the trabeculae (including the hypophysial plate) and the anterior halves of the parachordals we shall call the hypophysial fontanelle. The floor of the membranous cranium occupying this fontanelle forms the roof of the hypophysial canal. This canal is a short tube which opens posteriorly into the pharynx, anteriorly and superiorly into the nasal tube and nasal capsule. The floor of the hypophysial canal, which is a part of the roof of the pharynx, is supported by the median unpaired hypophysial plate (Pl. XXII, Fig. 6; Pl. XXIII, Fig. 7, *Hp*). It is a flattened cartilaginous plate, very thin posteriorly, but thicker anteriorly. At the posterior end the plate spreads out into two lateral processes, which are sometimes bilobed at the tips. These processes, together with the posterior end of the body of the plate, support the posterior margin of the valvular septum between the hypophysial and pharyngeal canals. At the junction of the posterior third with the anterior two-thirds of the hypophysial plate, it widens out laterally on each side to fuse with the corresponding anterior ends of the trabeculae, as previously described. So that the trabeculae, with their hypophysial expansion and the parachordals, completely encircle the hypophysial canal. Near the anterior end the hypophysial plate divides into two antero-lateral processes (Fig. 7, *k*) which are closely attached by ligaments to the inner sides of the palatine bars, a short distance behind their connecting commissure (*cm*).

The *olfactory capsule* as distinct from the entire olfactory chamber (Pl. XXII, Figs. 5, 6, *oc*) is a saccular structure directly in front of, and in size corresponding to, the membranous cranium, whereas the whole chamber is tubular in form. Anteriorly and inferiorly the capsule is open, communicating with the nasal tube and hypophysial canal. The posterior wall is formed by the anterior wall of the cranium, and is perforated near the dorsal margin by a row of foramina on each side which transmit the large branches of the olfactory nerves. The lateral and dorsal walls of the olfactory capsules are supported by a framework of cartilage which may be described as

consisting of nine longitudinal bars and two transverse connecting bars, an anterior and a posterior.

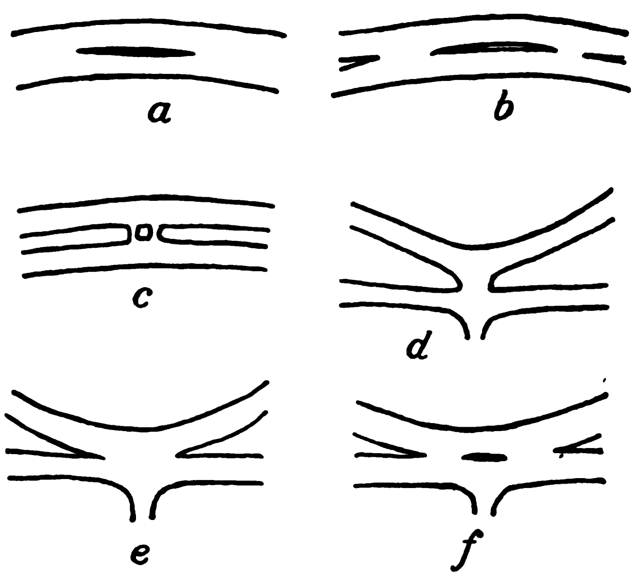
Of the nine longitudinal bars, seven are dorsal and two lateral. The seven dorsal bars are slender parallel rods, separated by spaces wider than the width of a bar. These bars support the roof of the olfactory capsule and correspond to the seven folds of mucous membrane which hang from the roof inside the olfactory capsule. The lateral bars are two somewhat irregular flattened cartilaginous plates which support the lateral walls of the olfactory capsule. The exact shape of these cartilages, which we shall call the *lateral plates*, varies in different specimens. Anteriorly a process is given off from the inferior angle, which runs forward and connects with the end of the last nasal arch. The anterior superior angle of the plate is connected with the end of the anterior connecting bar. The anterior portion of the lateral plate extends in a longitudinal direction. Posteriorly, however, the plate curves around, extending downward and inward toward the median line under the olfactory capsule. The posterior ends of the two plates do not fuse, but end in the inferior wall of the capsule near each other. A short distance from the posterior ends of the lateral plate a slender process is given off posteriorly, which is closely connected with the corresponding trabecula near the point of attachment to the palatine bar. A case of actual fusion between the lateral plate process and the trabecula has not been observed, however.

The posterior connecting bar is a narrow strip placed transversely across the roof of the olfactory capsule. It connects the posterior extremities of the nine longitudinal bars. The anterior connecting bar is a similar band, transversely placed, and giving attachment posteriorly to the anterior ends of the nine longitudinal bars. Anteriorly the anterior connecting bar gives off three processes which connect it with the last nasal arch. Thus, by means of these three connecting processes, together with the anterior processes from the lateral plates, the space between the last nasal arch and the anterior margin of the olfactory capsule is divided into four parts — two dorsal, somewhat elliptical, and two lateral, nearly circular.

The *nasal tube* (Plate XXII, Figs. 5, 6, *NT*) is a direct anterior continuation of the olfactory capsule. It is slightly funnel-shaped, being widest at the anterior end, and narrowest a short distance in front of the posterior end. The length of the nasal tube is greater than that of the olfactory capsule and cranium combined. The nasal tube and the olfactory capsule have a combined length about twice that of the cranium. Anteriorly the nasal tube opens to the exterior. Posteriorly it communicates with the olfactory capsule and the hypophysial tube, as previously described. The membranous wall of the tube is supported dorsally and laterally (and to some extent ventrally) by a series of cartilaginous nasal arches. When viewed from the sides, or from above, these arches appear as rings; but when viewed from below, it is seen that the ventral fourth of the ring is lacking. The nasal arches are usually nine in number, but sometimes eight or ten. The anterior four, and the posterior two arches have cartilaginous connecting processes; the remaining arches are independent. The anterior arch is the largest and widest. It is inclined sharply forward, its plane making with the horizontal plane an angle of about 45°. The anterior, or first arch is connected with the second by a median dorsal connecting process. Inferiorly, the first four arches end on each side in a longitudinal connecting bar. This bar ends in two terminal processes. The anterior process extends downward, inward, and forward, curving around and running forward parallel to the corresponding process from the opposite side. The two processes end near each other in the anterior inferior margin of the nasal tube, but do not connect, either with the labial cartilages or with each other. (In one case the two processes were found fused together, so that a complete cartilaginous ring was formed surrounding the anterior end of the nasal tube.) The posterior terminal processes of the connecting bar arise opposite the ends of the third and fourth arches. They are short, extending downward, inward and forward, ending in a free tip. The posterior two nasal arches are either fused together in the median dorsal line, or connected by a short process. Their ends are not connected. The last nasal arch connects with the cartilages

of the olfactory capsule by five processes, one median, two lateral, and two ventral, as already described. The penultimate and antepenultimate arches always appear concave forwards, when viewed from above.

The extraordinary degree of variation in the external form of Bdellostoma, and especially in the number of gills and teeth, is a fact which has already been emphasized by Dr. Ayers. It is even more remarkable to find a similar variation in the more deeply lying structures, including the skeletal parts.



Some of the more important variations have already been referred to, but in order to give a more adequate idea of the actual amount of variation, we shall give as an example the main points of difference found in the nasal arches of a dozen specimens taken at random.

The nasal arches are found to vary to a considerable extent in number, form, and size, both relative and absolute. In number, as has been stated, the nasal arches vary from eight to ten, but they are usually nine in number. In this count the two transverse bars of the olfactory capsule, though serially homologous with the nasal arches, are not included. The

number of arches seems, in general, to vary according to the size of the specimen, but this is by no means always the case. In one instance a very small specimen (about fifteen inches long) possessed ten nasal arches. In an 8-arched form the fifth arch was unusually wide, and was divided in the dorsal portion by a small slit (Fig. *a*), indicating the fusion of two arches. In a 10-arched form a rudimentary eleventh arch was represented by a lateral piece between the sixth and seventh arches on the right side, which extended dorsally nearly to the median line. Below, it fused with the seventh arch near the end. On the left side in this same (seventh) arch the lower end was bifurcated. In the same specimen there was a short process projecting backward from the sixth arch, a little to the right of the median line. In a 9-arched form the fifth and sixth arches were connected by a median longitudinal bar. In another 9-arched form the fifth and sixth arches were partly fused together dorsally, a small slit separating them in the median line, as shown in Fig. *b*. In a 10-arched form the sixth and seventh arches were somewhat similarly joined on each side of the median dorsal line, as in Fig. *c*. The last two arches were always found joined in the median dorsal line. Usually this was accomplished by a short longitudinal bar, as in Fig. *d*; but in several cases the two arches were partly fused, as in Fig. *e*, and once as in Fig. *f*. The anterior arch is wide and thin, usually perforated by from two to four circular foramina on the dorsal side. In one case the arch was found unperforated. It was usually smooth on the anterior margin, but in one case it was found marked by several irregular notches. The lateral plates of the olfactory capsules were found in a few instances perforated by two foramina, but usually unperforated. They vary considerably in shape and extent, as previously stated. Having completed the description of that part of the skull which constitutes the smaller dorsal tube, we shall now consider those structures which surround and support the larger ventral tube. In the antero-lateral region, just below the level of the floor of the nasal tube, are two bars, the *cornual cartilages* (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7, *cc*). They are a pair of slender cartilaginous

rods, lying in the same horizontal plane, but curved so as to be convex outward. They are closest together posteriorly, where they are attached on each side of the palatine commissure (*cm*). Anteriorly they diverge laterally and curve around so that the most anterior portions run parallel and end in a slender tip on each side of the nasal tube, a short distance behind its anterior end. The anterior ends of the cornual cartilages are connected by ligaments with the lateral labial cartilages at the base of the first tentacular cartilage.

In the median line between the cornual cartilages, and directly under the floor of the anterior portion of the nasal tube, is the unpaired *subnasal cartilage* (Pl. XXII, Fig. 6; Pl. XXIII, Fig. 7, *N*). This is a rather strong, fusiform rod, thickest in the middle portion, somewhat nearer to the anterior end, and tapering anteriorly and posteriorly. Near the posterior end it becomes flattened and at the extremity expands laterally into two small processes. The posterior end is attached to the dorsal side of the palatine commissure, just in front of its posterior margin. Anteriorly it attaches in the median line to the transverse labial cartilage.

The *labial cartilages* (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7) support the oral margin dorsally and laterally, and give attachment to the tentacular cartilages. The *transverse labial cartilage* is an unpaired transverse bar lying in the dorsal portion of the oral margin. The lateral halves meet at an angle in the median line, so that the bar may be described as an arch, concave forward. Laterally the ends of the bar are directly continued into the second pair of tentacular cartilages (t_2). These extend outward and forward, tapering gradually to a point. In the median line, posteriorly, the transverse labial cartilage is attached to the anterior end of the subnasal cartilage, as already mentioned.

The *lateral labial cartilages* (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7, *Lc*) are a pair of somewhat slender cartilaginous rods lying in the lateral margin of the mouth, surrounded by muscles, and supporting the first and third pairs of tentacular cartilages. Posteriorly they are attached to the antero-external angles of the basal plate. From this point they curve forward,

upward, and inward. A little below the level of the floor of the nasal tube, and almost directly below the anterior ends of the cornual cartilages, they give off, on each side, a process which continues outward and forward as the third tentacular cartilage (t_3). Like the second pair, these cartilages are conical in shape, tapering gradually to a point. A little further upward and inward, the lateral labial cartilage gives off a short process (*mp*) which extends inward toward the median line, and abuts against the side of the nasal tube, just above the longitudinal connecting bar. This process is attached to the nasal tube by a membranous ligament, but is not joined directly to any cartilages of the nasal tube. The lateral labial cartilage now curves outward, and then turns sharply upward, forward, and inward to terminate in the long, slender, conical cartilage of the first tentacle (t_1). It is at the base of this tentacle that the ligament connecting with the anterior end of the cornual cartilage is attached. The fourth tentacular cartilages (Pl. XXII, Fig. 6; Pl. XXIII, Fig. 7, t_4) are remarkable for their shape and position. They are irregular, somewhat elliptical, thin plates of cartilage, nearly vertical in position, and curved laterally so as to be slightly convex anteriorly. From the upper end a short process extends upward, forward, and outward toward the base of the third tentacle, with which it is connected by a ligament. The cartilaginous plates of the fourth tentacles are not fused with any other cartilages, but are supported by the surrounding muscles and connective tissue. It is questionable whether they are true tentacles in the sense that the other three pairs are. In life they appear as slight folds in the skin on the infero-lateral margin of the oral opening. The floor of the skull is formed by a large, strong, trough-shaped cartilaginous apparatus, the *basal plate* (Pl. XXII, Figs. 5, 6; Pl. XXIII, Figs. 7–9, B, B', B''). The basal plate may be divided into three segments, an anterior (B), a middle (B'), and a posterior (B''). The anterior segment (Pl. XXIII, Figs. 8, 9, B) is made up of two pairs of flattened longitudinal bars, an inner and an outer pair. The inner pair (*Ai*) is the smaller. In the anterior two-thirds they are fused together in the median line, no trace of the fusion showing on the ventral side, and only a

faint indication on the dorsal side. This anterior fused portion is divided by a transverse suture which is concave forward, and is well marked on the ventral side, but less distinctly on the dorsal side. In the posterior third, the inner pair of bars diverge slightly, enclosing in the angle between them the anterior half of a diamond-shaped space. The posterior ends are attached to the inner thirds of the anterior ends of the median cartilages (*Mc*). At the anterior end, the inner bars, just in front of the fused portion, are extended outward, forward, and upward as a pair of short, flattened processes. The flattened inner bars are not placed in the horizontal plane, but are inclined toward each other so that a dorsal groove is formed by their meeting in the median line. This groove is shallow posteriorly but deeper anteriorly. In it the median portion of the overlying dental plate glides. The anterior continuation of this groove is formed by the anterior processes, whose faces look forward, as well as upward and inward. An anterior notch is thus formed, through which the tendon of the protractor muscles of the dental plate glides. The outer pair of bars belonging to the anterior segment is larger, thicker, and stronger than the inner (Pl. XXIII, Figs. 8, 9, *Ac*). They are somewhat flattened dorso-ventrally, and are wider at the anterior end. Their posterior ends are attached to the outer two-thirds of the anterior ends of the median cartilages, besides the posterior ends of the inner pair. Anteriorly, the outer bars at first diverge laterally and then curve inward slightly toward the anterior ends, which are truncated and lie a short distance in front of the anterior ends of the inner bars. The external angles of the anterior ends give attachment to the lateral labial cartilages (*Lc*). The outer bars are separated from the inner pair by a narrow longitudinal slit. The ventral surfaces of the outer bars are convex, the dorsal surfaces nearly plane. The latter are inclined so as to be nearly in the same plane as the corresponding inner bar, so that they aid in forming the grooved dorsal surface on which the dental plate glides. The outer bars are nowhere directly connected with the inner, the two being bound together by strong ligamentous bands. The middle segment, *B′*, of the basal plate lies immediately behind the

anterior segment, with the cartilages of which it is connected by a slightly movable joint. The middle segment is made up of a pair of flattened plates, large, thick, and strong, which are closely united in the median line, excepting at the anterior end (Pl. XXIII, Figs. 8, 9, *Me*). In the anterior fifth, the plates diverge laterally and enclose the posterior half of the diamond-shaped space which extends forward between the posterior ends of the inner bars of the anterior segment. At the postero-external angle on each side a short cylindrical process (Pl. XXIII, Figs. 7, 8, *sb*) is given off which extends upward, outward, and backward to fuse with the lower ends of the first two branchial arches (br_1 and br_2). The plates of the median segment are nearly rectangular in outline, thicker externally than internally, and curved so as to be convex ventrally and concave dorsally. They are about as long as the cartilages of the anterior segment and as wide as both anterior pairs combined. They are inclined so as to form a continuation of the trough described in the anterior segment, the chief difference being that the trough is narrower and deeper in the middle segment. Moreover, each of the plates of the middle segment has two longitudinal grooves on its dorsal surface. The first is along the internal margin and unites with that of the opposite plate to form a median groove which transmits the main division of the *M. retractor mandibuli* tendon. The second groove is along the median dorsal surface, and serves to transmit, on each side, the lateral division of the same tendon (see Pl. XXIII, Figs. 10, 11, *t*).[1] Anteriorly, as already described, the middle segment articulates with the cartilages of the anterior segment. Posteriorly it is immovably attached to the third segment, B''.

The third segment, B'', forms the posterior division of the basal plate, and is considerably longer than both the first and second segments combined. It is a heavy, unpaired structure, corresponding in width to the middle segment anteriorly,

[1] It is worthy of mention that on the ventral surface the cartilages of the median segments show distinct longitudinal markings on each side, which may be obsolescent sutures indicating that the pair of plates is composed of *two* fused pairs, corresponding to the two pairs of the anterior segment.

but tapering to a point posteriorly. It has a deep dorsal groove corresponding to that formed by the anterior segments, and transmitting the tendon of the *M. retractor mandibuli.* Consequently it is *U*-shaped in cross-section. Posteriorly this groove flattens out, and the third segment of the basal plate becomes continuous dorsally and laterally with the fibers of the *constrictor musculi mandibuli* muscle. It is quite evident that the third segment is not a true cartilage, but is formed by a chondroidal modification of the tendon of the "constrictor" muscle. It is white in color when preserved in formalin, contrasting strongly with the reddish-colored anterior cartilaginous segments. A histological examination shows it to be made up of a very peculiar tissue, more nearly related to notochordal tissue than to the cartilage found in the other skeletal parts.

The *dental plate* (Pl. XXII, Fig. 6, *D.*; Pl. XXIII, Figs. 10, 11) is a cartilaginous structure resting upon the anterior segment of the basal plate and supporting the four rows of horny teeth. It is a flattened framework, consisting of two arches, an anterior and a posterior. The anterior arch is made up of a median piece (Pl. XXIII, Fig. 11, *Md*), two lateral plates (*aa*), and two pairs of connecting processes (*r*, *v*).

The median piece is a thin elliptical plate, with its long axis in the median line. It is curved from side to side, the downward convexity fitting into the dorsal groove of the anterior segment of the basal plate. The anterior end is somewhat depressed where it passes into the protractor tendon.

The anterior half of the median piece extends farther forward than the anterior margins of the lateral plates. Connecting the median piece with the lateral plates are two pairs of lateral processes (Fig. 11, *r*, *v*). The anterior processes (*r*) are short and are given off from the middle of the median piece on each side, and extend backward, outward, and slightly upward to the antero-internal angles of the corresponding lateral plates. The posterior processes (*v*) are longer. They extend from the posterior angles of the median piece on each side, backward, outward, and upward to join the lateral plates about the middle of their internal margin. The lateral plates

(*aa*) are large, thin, oval sheets of cartilage, broad anteriorly and narrower posteriorly. They are curved slightly so as to be somewhat convex upward and concave downward. Their ventral surfaces rest directly upon the external bars of the anterior segment of the basal plate. The upper surfaces of the two plates are, therefore, correspondingly slightly inclined toward each other in the normal position. The external margins of the plates are smooth and rounded. The internal margins are nearly straight, and approach each other in the median line anteriorly (being separated from each other only by the median piece and anterior processes) but diverge posteriorly, being widely separated at the posterior ends. The internal margins are connected with the median piece, as already described. The posterior processes are separated from the anterior, and from the lateral plate, on each side, by a long, narrow slit, parallel to the inner margin of the lateral plate. On account of this slit, the posterior processes, which are long and slender, have the appearance of a third arch closely united with the anterior arch. At the posterier extremity, each lateral plate has two processes, an external (*e*) and an internal (*i*). The external process curves around upward and inward, and ends freely in a fold of the mucous membrane just behind the inner row of teeth. The internal process curves backward, upward, and inward. It fuses with the end of the lateral bar of the posterior arch. On their dorsal surfaces the lateral plates bear the matrices in which are imbedded the four rows of teeth. The posterior arch (Pl. XXIII, Figs. 10, 11, *pa*) is composed of two curved flattened bars. These bars are rather wide anteriorly, but narrow abruptly as they approach, to fuse with each other in the median line by a short commissure. The anterior half of the arch curves downward to form a convex projection corresponding to that formed by the median piece of the anterior arch, and fitting in the median dorsal groove of the basal plate below. The posterior halves of the lateral bars diverge posteriorly and become narrower. Near the posterior end of each there is a slight enlargement, at which the bar turns sharply outward to fuse with the internal process (*i*) from the lateral plates of the

anterior arch. The posterior arch does not support any teeth. The tendons of the retractor, as well as the protractor, muscles are attached, not to the cartilages directly, but to the strong fibrous membranes which surround them.

The foregoing description has included the skeletal parts making up the dorsal and ventral portions of the skull and the cartilages of the mouth region. The lateral walls of the skull, especially in the posterior region, are supported by a framework of cartilages ("Schlundkorb" of Johannes Müller). A comparison of Figs. 5, 6, and 7 will show that this framework is, for the most part, composed of a number of vertical arches, connected on each side by two longitudinal bars, a dorsal and a ventral. The cartilages of this framework, as we shall see, are really metamorphosed visceral arches. Beginning anteriorly, we find the lateral walls of the skull, in front of the auditory capsules, and external to the trabeculae, supported by the heavy irregular *palato-pterygo-quadrate* bars (Plate XXII, Figs. 5, 6; Plate XXIII, Fig. 7, *PQ, Pl.*). The *palato-pterygo-quadrate* on each side has two main divisions — an anterior, the palatine bar, and a posterior, the *pterygo-quadrate* cartilage, *PQ*. The *palatine bars* (Figs. 5, 6, 7, *Pl*) are a pair of large, strong, cartilaginous rods, extending along either side of the nasal capsule and the posterior fourth of the nasal tube, at about the level of the floor of the latter. The olfactory capsule and nasal tube rest upon the flattened surfaces of the palatines, which look upward and inward, but there is no cartilaginous connection between them. Anteriorly the palatine bars converge slightly toward the median line. Finally they turn abruptly toward each other and are connected at the anterior end by a short, broad, flattened transverse commissure (Fig. 7, *cm*) which faces upward and slightly forward. To the inner margins of the palatines, a short distance behind the commissure, are attached the anterior processes of the hypophysial plate. On the upper surface of the commissure, in the median line near the posterior margin, is attached the posterior end of the subnasal cartilage. At the anterior external angles are attached the posterior ends of the cornual cartilages, as previously mentioned. At the posterior

extremity the palatine bar is connected by a short process with the corresponding trabecula. The main bar of the palatine passes directly backward and downward into the anterior process of the pterygo-quadrate.

The posterior division of the palato-pterygo-quadrate cartilage is the *pterygo-quadrate* (Figs. 5, 6, 7, *PQ*). This cartilage is triradiate, being composed of three large flattened processes, the anterior, the superior, and the inferior. The anterior process runs forward, upward, and inward, to fuse with the posterior end of the palatine bar. It is flattened and slightly curved, its outer surface looking outward, upward, and slightly forward. Posteriorly it fuses into the superior and inferior processes. The superior process is a flattened bar passing upward, backward, and inward. On reaching the level of the cranial floor it passes inward and slightly forward and fuses with the trabecula just in front of the auditory capsule. The anterior margin of the superior process, the upper margin of the anterior process, and the external margin of the trabeculae together enclose a large oval fenestra (1). The anterior and superior processes together constitute the subocular arch. In its upper portion the superior process gives off posteriorly a large flattened connecting piece which runs directly backward to fuse with the hyoid arch, a short distance from the auditory capsule. The posterior margin of the superior process and the superior margin of the connecting piece are separated from the external wall of the auditory capsule by a narrow, curved fenestra (2). The inferior process runs outward, downward, and backward, enlarging at the lower extremity, where it fuses with the hyoid arch. The inferior process is flattened laterally. Its upper margin, together with the posterior margin of the superior process, the inferior margin of the connecting piece, and the anterior margin of the hyoid arch, encloses a large fenestra (3) nearly circular in general outline.

The hyoid arch (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7, *Hy*) is a flattened, irregular, vertical bar placed behind the pterygo-quadrate. The upper end fuses with the posterior half of the external wall of the auditory capsule. From the point of fusion the hyoid arch extends outward and downward, almost

immediately expanding into a broad plate which fuses anteriorly with the connecting piece from the pterygo-quadrate, as previously described, and posteriorly, at the same level, with the anterior end of the superior lateral bar (*b*). The hyoid arch then narrows somewhat and continues outward and downward, its anterior margin forming the posterior boundary of the large circular fenestra (3). From the anterior margin of the hyoid a short flattened oval process extends forward, nearly to the center of this space. Inferiorly the hyoid arch again broadens out, connecting anteriorly with the inferior process of the pterygo-quadrate, and posteriorly with the inferior lateral bar (*b'*). In the angle between the hyoid and the inferior lateral bar a short process curves upward, backward, and then slightly downward, ending freely in the large fenestra (4). This fenestra is bounded anteriorly by the posterior margin of the hyoid, above by the superior lateral bar, below by the inferior lateral bar, and posteriorly by the upper end of the second branchial bar (br_2). The first branchial arch (Pl. XXII, Figs. 5, 6; Pl. XXIII, Fig. 7, br_1) is a slender cartilaginous bar arising from the superior lateral bar at some distance behind the hyoid. It curves at first outward, backward, and downward, over the middle part of the fenestra (4), previously described; then it curves forward and inward to fuse with the posterior process of the second basal segment (*sb*), together with the lower end of the second branchial arch (br_2).

The superior lateral cartilage (Figs. 5, 6, 7, *b*) arising anteriorly from the upper portion of the hyoid arch, and continuing directly backward, gives attachment externally to the first branchial arch, as just noted. Then it continues horizontally backward and finally curves slightly outward and downward, broadening out into a flattened, somewhat triangular plate, which terminates posteriorly in a sharp apex. The lower angle of the triangle is continued into the upper division of the second branchial arch (Figs. 5, 6, 7, br_2). The upper division extends downward into a more or less prominent process, then turns sharply backward and fuses with the inferior lateral bar (*b*). This bar, as previously noted, arises anteriorly from the inferior portion of the hyoid, being at first a rather strong

bar, which becomes more slender posteriorly. After fusing with the upper division of the second branchial it passes backward and slightly upward, ending in a sharp apex just below the posterior end of the superior lateral bar. Near the posterior end the lower division of the second branchial arch begins from the inferior margin and extends forward, downward, and inward, to fuse with the posterior process (*sb*) of the second segment of the nasal plate, as previously described.

Lying in the median dorsal pharyngeal wall, between the posterior portions of the superior lateral bars, is a flattened plate, the suprapharyngeal cartilage (Pl. XXII, Figs. 5, 6, *S*). It is composed of a body and two lateral horns. The body is a flattened, nearly circular plate, somewhat wider than the notochord. The plate is usually perforated by two openings lying one behind the other in the median line, but there is considerable variation in different specimens. On each side of the plate is given off a slender lateral horn which extends outward and slightly downward, with a sharp apex ending free near the tip of the superior lateral bar. The lateral horns are continued anteriorly with the anterior connecting processes (*a*) from the velar cartilages. From the body of the suprapharyngeal cartilage there is also given off anteriorly, in the median line, a short process that fuses with the vertical median connecting process (*m*), which passes directly downward to the underlying velar cartilages.

The velum, or pharyngeal valve, is formed by an evagination of the mucous membrane from the dorsal and lateral walls of the pharynx. The velum projects backward in the pharyngeal cavity and is supported by a framework of velar cartilages. This includes the external and internal lateral bars, connecting bars, and connecting processes. The *external lateral velar bars* (Pl. XXII, Fig. 6; Pl. XXIII, Fig. 7, *V*) are the largest and support the lateral margins of the velum. Anteriorly the bar is large, thick, strong, and flattened laterally. Posteriorly it tapers very gradually to a point. The rod is slightly curved, the posterior end being nearer the median line. The anterior end of the bar is continued into a large, strong, articular process, extending outward and slightly downward. This process

is firmly attached by ligaments to the pharyngeal wall, just anterior and internal to the short anterior process from the hyoid arch. About the middle of the external lateral velar bars, in the region of the first branchial arch, the anterior ends of the internal lateral velar bars are attached. From this point the external velar bar on each side passes backward and slightly inward, tapering to a point in the posterior margin of the velum a short distance behind and below the posterior end of the corresponding superior lateral velar bar. The *internal lateral velar bars* (Figs. 6, 7, *V'*) are smaller than the externals. Beginning at their attachment to the middle point of the internal margin of the external velar bars, they pass backward and inward until they are directly over the lateral margins of the basal plate. Here they are connected by a transverse velar bar (*ab*). The internal lateral velar bars then pass directly backward parallel to each other. A second velar transverse bar (*pb*) connects them with the lateral velar bars and the anterior connecting velar bar, and encloses a fenestra almost square. The internal lateral velar bars then continue backward and slightly outward, each tapering to a point in the posterior margin of the velum near the posterior end of the corresponding external lateral velar bar. The posterior transverse velar bar (*pb*) has a process extending directly backward in the median line which ends in the margin of the velum. The posterior end of this process is usually bifid. The anterior transverse velar bar (*ab*) has three connecting processes. The median process (Fig. 7, *m*) passes at first backward, then turns directly upward and fuses with the anterior median process of the suprapharyngeal cartilage. The anterior connecting processes (*a*) arise one on each side of the median line and curve forward, upward, and backward, to unite with the anterior surfaces of the lateral horns of the suprapharyngeal plate (Figs. 5, 7, *a*). These connecting processes form an elastic apparatus by means of which the velum, under ordinary conditions, is suspended above the floor of the pharynx.

In the posterior part of the fascia of the club-shaped muscle body are found two whitish elongated bars lying in the median line, one above the other. These are the *superior* and *inferior*

chondroidal bars (Pl. XXII, Fig. 6, *cs*, *ci*). These bars are somewhat flattened dorso-ventrally and serve for the attachment of muscles and fascia. The superior bar is somewhat larger and placed slightly anterior to the inferior bar. These bars are not true cartilage but are composed of a chondroidal tissue similar to that of the posterior segment of the basal plate. They are not, therefore, to be regarded as skeletal derivatives of the visceral or branchial arches, but simply as chondroidal modifications (*i.e.*, condensations of connective tissue) in the muscular fascia.

The gill cartilages (Pl. XXII, Fig. 6, *gb*) are a remarkable series of small cartilaginous bars which are so bent as to encircle the walls of the external gill passages lying near the external gill openings. The broad faces of the bands, when straightened out, present a somewhat semilunar shape (see Fig. 12), being composed of a wide central portion and slender extremities. The central portion is often perforated, as shown in Fig. 12. Of the lateral pieces, the outer is longer than the inner. When in position the wide central portion of the band is applied to the posterior surface of the tube, the band surrounding it so that the ends approach each other on the anterior surface of the gill passage. The ends are at a slightly lower level than the central portion of the gill cartilage, and consequently nearer the mouth of the passage. In many cases the ends of these gill cartilages fuse together, forming a complete ring around the tube. There is much variation in different specimens in this respect. It is evident that these gill cartilages serve to keep the mouths of the gill passages open under ordinary circumstances.

Since the myotomes and gills of the opposite sides are not opposite but alternate, the gill bars, of course, have the same arrangement.

The position of the gills and gill bars, however, does not seem to have any fixed relation to the position of the myotomes, for the openings of the external passages correspond sometimes to myotomes, sometimes to intermuscular septa. They are, therefore, neither regularly opposite to, nor alternate with, the myotomes.

Moreover, the relations which exist on the opposite sides, even of the same animal, are quite different in all the specimens examined. The heterogeneity of segmental arrangements in myxinoids, of which this is an example, is one of the most remarkable characteristics of their anatomy.

The last external gill passage on the left side always, so far as our observations yet go, opens into the oesophago-cutaneous duct, instead of having an independent opening on the surface of the body. In the wall of the oesophago-cutaneous duct is a cartilage of peculiar shape (Pl. XXII, Fig. 6, *oes. c.*; Pl. XXIII, Fig. 13). This is the only part of the gill-cartilage system heretofore observed in Bdellostoma.

It is irregular in shape and varies considerably in different specimens. Apparently it has been derived by the fusion of two cartilages such as we find in the other gill tubes; one corresponding to the last left gill tube, and the other to the oesophago-cutaneous duct. It is an important fact that one process from this cartilage (Pl. XXIII, Fig. 13, *h*) often passes up the duct wall *and into the wall of the oesophagus, i.e., pharynx.*

The number of gill cartilages (including that of the oesophago-cutaneous duct), of course, corresponds to the number of gills. This number, as Dr. Ayers has pointed out, varies to a remarkable degree. In 354 specimens of Bdellostoma dombeyi collected by him from Monterey Bay in the spring of 1892, the following variations occurred:

101	individuals	had 11	gills	on	both sides.
26	"	" 11	"	"	one side,
		and 12	"	"	the other side.
208	"	had 12	"	"	both sides.
11	"	" 12	"	"	one side,
		and 13	"	"	the other side.
8	"	had 13	"	"	both sides.
354					

Of the eleven to twelve variation, where the position of the gills was noted, four had eleven gills on the right side and twelve on the left; while four were just the reverse, with twelve gills on the right side and eleven on the left. The

same alternate variation was true of the twelve to thirteen variety.

In 162 specimens collected by Mr. Jackson in Monterey Bay in July, 1897, the following variations were found:

Number of Individuals.	Number of Gills on Left Side.	Number of Gills on Right Side.
1	10	10
50	11	11
17	12	11
88	12	12
1	12	13
2	13	12
3	13	13
162		

The variation in the number of gills and hence of gill cartilages is, therefore, in no way dependent upon the formation of the oesophago-cutaneous duct, which is always upon the left side.

Neither does the variation bear any constant relation to the size or sex of the specimen. The average length of the 162 specimens was 18.3 inches (varying from 14 to 23 inches). The 10-gilled form measured 19 inches, while one of the 13-gilled forms measured only 17 inches.

Behind the gill region there is a considerable portion of the body devoid of any skeleton, excepting those structures already mentioned in connection with the notochord. In the posterior region of the body, however, we find the large caudal fin supported by an extensive set of cartilages (Pl. XXIII, Fig. 14). The caudal fin arises about the middle of the body in the median dorsal line as a slight ridge of the integument, which gradually increases in height and is well developed posteriorly. It passes around the posterior end of the body and terminates on the ventral side in the median line just behind the cloaca.

For convenience of description, the caudal fin may be divided into a dorsal fin and a ventral fin (Pl. XXIII, Fig. 14, *DF*, *VF*). Each of these is supported by a number of slender, cartilaginous fin-rays, the most of which are fused at their proximal ends with a pair of longitudinal bars, dorsal and ventral.

The fin-rays are imperfectly segmented, and are surrounded by a sheath of connective tissue, which is also constricted in places, but not always in agreement with the cartilage segments. The bodies of the fin-rays are conical, their bases being the proximal ends. They are often bifurcated at their distal ends, sometimes twice, so that each ray may have three or four terminal twigs.

In the anterior portions of the fins one can recognize a general segmental arrangement of the fin-rays, though the agreement between myotomes and fin-rays as well as gills, slime glands, etc., is by no means perfect. Near the posterior end of the body the fin-rays are much more numerous than the myotomes.

The *dorsal fin* (Fig. 14, *DF*) extends through the body region occupied by about the fiftieth to the ninety-fifth (last) myotome. Anteriorly the first three or four fin-rays are very small and scattered, being imbedded in the median dorsal septum just outside the muscles. A little farther back the rays are better developed. Their bases lie in the roof of the neural tube (skeletogenous layer), and they extend obliquely backward and upward through the median dorsal septum to the margin of the fin. The proximal ends of the fin-rays are therefore imbedded between the muscles of the right and left halves of the body, while the distal ends lie between the layers of skin forming the fin fold. The bases of the most anterior rays are free and independent. A little farther back a slender cartilaginous process extends forward in the median line from the base of each fin-ray. Each ray with its corresponding process is at first independent; but posteriorly the processes become larger and longer, and finally (about seventy-fifth to eightieth myotome) they fuse together with the bases of the fin-rays to form the longitudinal *median dorsal bar* (Fig. 14, *MD*). This bar is slender anteriorly and triangular in cross-section, but posteriorly it passes around the end of the tail into the vertical plate (see Pl. XXIII, Fig. 15, *MD*). The median dorsal bar extends along the roof of the neural canal. To it are fused twenty-five to forty fin-rays. (Total number of fin-rays in dorsal fin, fifty to sixty.) In some cases small extra fin-rays are found in the

fin between the outer ends of the ordinary fin-rays, but not connected with them. The dorsal fin is tallest a short distance from its posterior end. Posteriorly it is directly continuous around the posterior end of the body with the ventral fin. The median dorsal bar is continuous with the median ventral bar.

The *ventral fin* (Fig. 14, *VF*) begins in the median line just behind the cloaca, and extends from the seventy-fifth to the ninety-fifth myotome (posterior end of the body). Its fin-rays are from thirty to thirty-five in number. They are all well developed and branched at the outer ends, especially in the posterior region, where the branches are in some cases longer than the main stalk. The rays of the ventral fin form two divisions. Those of the anterior division (eleven to fifteen) are larger, and approximately segmental in arrangement. Their bases end freely above, and are not directly connected with the notochord or the median ventral bar. From their bases they extend downward and slightly backward in the median line. The first ray is the largest and longest, extending back over the median dorsal roof of the cloaca.

Beginning about the eighty-fifth myotome, the fin-rays of the posterior division are smaller and more closely crowded together, being about twenty, corresponding to the last ten myotomes. Their upper or proximal ends are fused with a large vertical plate, the *median ventral bar* (Fig. 14, *MV*). This cartilage arises anteriorly about the cloacal region as a *pair* of slender bars running along the infero-lateral angles of the notochord in the skeletogenous layer. Anteriorly each of these lateral bars breaks up in some cases into a short chain of small cartilage patches, *segmentally arranged*, corresponding to the neighboring myotomes. Posteriorly the lateral bars become wider, and finally fuse across the median line below the notochord, to form the median ventral bar. This portion of the bar lies above the anterior division of the ventral fin-rays, but is not fused with them. About the region of the eighty-fifth myotome the median ventral bar suddenly enlarges into a vertical plate, with which the remaining fin-rays are fused (see Fig. 14). The anterior inferior angle of this plate extends forward as a process (Fig. 14, *c*) which forms a *T*-shaped plate,

flattened dorso-ventrally. This plate forms the ventral wall of a pocket in which the posterior end of the large dorsal abdominal vein lies, its main trunk terminating here. A similar structure has been described by Cleland for Myxine. In the anterior region the dorsal surface of the median ventral bar is merely in contact with the ventral surface of the notochord. Posteriorly, however, the ventral bar sends up lateral extensions around the sides of the notochord, so that the latter lies in a groove on the dorsal surface of the bar. Near the posterior end these lateral plates extend still farther up around the sides of the neural tube, so that the median ventral bar is *Y*-shaped in cross-section. The appearance near the end of the notochord is shown in Pl. XXIII, Fig. 15. Just behind the plane of the section shown in this figure a cartilaginous band rises on each side from the median ventral bar, and fuses with the median dorsal bar, *forming a complete neural arch around the neural tube* (Pl. XXIII, Fig. 14, *r*). This arch lies just anterior to the last two myotomes. The posterior end of the neural tube is slightly dilated and surrounded by cartilage, excepting the upper lateral portions. The spinal cord itself *is not dilated* at the posterior end.

A very thin irregular sheet of cartilage is found in the wall of the cloaca, especially in the anal region (Fig. 14, *av*). It extends across the cloaca in the postanal septum. The development of this cloacal cartilage varies a great deal in different specimens. In a few cases it is found well developed, in others only to a slight extent. It is possible that this cartilage serves to expand the anal opening in anal respiration.

Exoskeleton.

The only skeletal parts which belong to the integument are the horny teeth. The *dorsal tooth* (Pl. XXII, Fig. 6, *dt*) is a single corneous conical structure in the roof of the mouth. Its base is imbedded in a firm, disc-shaped matrix which lies in the median line immediately below the palatine commissure (*cm*). The tooth is light brown in color, thick at the base, but slender toward the end, which curves downward and backward,

ending in a very sharp point. This tooth prevents the forward slipping of any object which is being subjected to the rasping action of the ventral teeth.

The *ventral teeth* are arranged in four rows, two upon each side of the dental plate (Pl. XXII, Fig. 6; Pl. XXIII, Fig. 10). The larger rows are anterior and external. Each tooth is somewhat conical, with a large hollow base, and a smaller apical portion which is somewhat flattened laterally. The free distal portion of each tooth curves upward, backward, and inward, tapering to a sharp point. The teeth of each row are united firmly to their bases, the corneous material of the teeth being continuous through an entire tooth row. The separate rows are not united in any way. Occasionally, however, the anterior and the posterior teeth of the row are not fused with the remainder. The teeth in each row decrease in size from before backward. They are yellowish-brown in color, and the number of teeth varies to a considerable extent.

In the following tables the formula used to indicate the number of teeth in the several rows is given in the subjoined diagram:

Left outer row.	Right outer row.
Left inner row.	Right inner row.

The limits of the variability in the teeth of Bdellostoma, so far as known, are as follows:

Bdellostoma from the Cape of Good Hope (Müller), 6 to 7 gills, $\frac{8}{7} | \frac{8}{8}$, $\frac{11}{11} | \frac{11}{11}$, $\frac{12}{11} | \frac{12}{12}$.

Bdellostoma from the coast of Chili, 10 gills, $\frac{11}{7} | \frac{11}{7}$ (Lacépède), $\frac{12}{11} | \frac{12}{11}$, $\frac{13}{12} | \frac{13}{12}$.

Bdellostoma from the coast of California, 11 to 13 gills, $\frac{9}{9} | \frac{9}{9}$, $\frac{12}{11} | \frac{12}{11}$.

In the California series examined by Dr. Ayers the dental formulae were as follows: In 22 individuals with 11 gills, 1 $\frac{10}{9} | \frac{9}{9}$, 1 $\frac{10}{10} | \frac{9}{10}$, 4 $\frac{10}{9} | \frac{10}{9}$, 1 $\frac{10}{9} | \frac{10}{10}$, 1 $\frac{10}{10} | \frac{10}{10}$, 1 $\frac{10}{10} / \frac{11}{9}$, 1 $\frac{10}{9} | \frac{11}{9}$, 1 $\frac{10}{10} | \frac{11}{10}$, 3 $\frac{11}{10} | \frac{10}{10}$, 1 $\frac{11}{11} | \frac{10}{10}$, 5 $\frac{11}{10} | \frac{11}{10}$, 1 $\frac{11}{11} | \frac{11}{10}$, 1 $\frac{12}{9} | \frac{11}{9}$, 2 $\frac{12}{11} | \frac{12}{11}$.

In 62 individuals with 12 gills the following dental formulae occurred: 1 $\frac{9}{9}\mid\frac{10}{10}$, 1 $\frac{9}{9}\mid\frac{9}{9}$, 8 $\frac{9}{9}\mid\frac{10}{9}$, 1 $\frac{9}{10}\mid\frac{10}{9}$, 1 $\frac{9}{10}\mid\frac{10}{10}$, 2 $\frac{10}{9}\mid\frac{9}{9}$, 1 $\frac{10}{10}\mid\frac{9}{9}$, 1 $\frac{10}{10}\mid\frac{9}{10}$, 10 $\frac{10}{9}\mid\frac{10}{9}$, 4 $\frac{10}{10}\mid\frac{10}{9}$, 6 $\frac{10}{10}\mid\frac{10}{10}$, 7 $\frac{10}{9}\mid\frac{10}{10}$, 1 $\frac{10}{9}\mid\frac{11}{9}$, 1 $\frac{10}{10}\mid\frac{11}{10}$, 1 $\frac{11}{9}\mid\frac{10}{9}$, 1 $\frac{11}{10}\mid\frac{10}{9}$, 10 $\frac{11}{10}\mid\frac{10}{10}$, 3 $\frac{11}{10}\mid\frac{11}{10}$, 1 $\frac{11}{10}\mid\frac{12}{10}$, 1 $\frac{12}{11}\mid\frac{12}{11}$.

On combining the dental formulae of the 11-gilled and 12-gilled variations, the following numbers were found to obtain in the 86 individuals whose dental formula was carefully examined on both sides of the dental plate.

Number of Individuals.	Dental Formula.	Number of Individuals.	Dental Formula.
1	$\frac{9}{9}\mid\frac{9}{9}$	2	$\frac{10}{9}\mid\frac{11}{10}$
8	$\frac{9}{9}\mid\frac{10}{9}$	1	$\frac{10}{10}\mid\frac{11}{9}$
1	$\frac{9}{10}\mid\frac{10}{9}$	2	$\frac{10}{10}\mid\frac{11}{10}$
1	$\frac{9}{10}\mid\frac{10}{10}$	1	$\frac{11}{9}\mid\frac{10}{9}$
3	$\frac{10}{9}\mid\frac{9}{9}$	1	$\frac{11}{10}\mid\frac{10}{9}$.
1	$\frac{10}{10}\mid\frac{9}{9}$	13	$\frac{11}{10}\mid\frac{10}{10}$
2	$\frac{10}{10}\mid\frac{9}{10}$	1	$\frac{11}{11}\mid\frac{10}{10}$
14	$\frac{10}{9}\mid\frac{10}{9}$	8	$\frac{11}{10}\mid\frac{11}{10}$
8	$\frac{10}{9}\mid\frac{10}{10}$	1	$\frac{11}{11}\mid\frac{11}{10}$
4	$\frac{10}{10}\mid\frac{10}{9}$	1	$\frac{11}{10}\mid\frac{12}{10}$
7	$\frac{10}{10}\mid\frac{10}{10}$	1	$\frac{12}{9}\mid\frac{11}{9}$
1	$\frac{10}{9}\mid\frac{11}{9}$	3	$\frac{12}{11}\mid\frac{12}{11}$
	Total number	86	

In the series of 162 specimens from Monterey Bay examined by Mr. Jackson, the following dental formulae were observed:

Branchial formula, 10–10:—1 $\frac{9}{9}\mid\frac{9}{9}$.

Branchial formula, 11–11:—1 $\frac{10}{9}\mid\frac{10}{8}$, 11 $\frac{10}{9}\mid\frac{10}{9}$, 4 $\frac{10}{10}\mid\frac{10}{10}$, 1 $\frac{11}{9}\mid\frac{11}{9}$, 3 $\frac{11}{10}\mid\frac{10}{9}$, 4 $\frac{10}{10}\mid\frac{11}{10}$, 2 $\frac{10}{10}\mid\frac{10}{9}$, 1 $\frac{10}{9}\mid\frac{11}{10}$, 1 $\frac{11}{9}\mid\frac{11}{8}$, 2 $\frac{11}{9}\mid\frac{10}{10}$, 3 $\frac{11}{10}\mid\frac{10}{10}$, 7 $\frac{11}{10}\mid\frac{11}{10}$, 1 $\frac{11}{10}\mid\frac{12}{9}$, 1 $\frac{11}{10}\mid\frac{12}{10}$, 1 $\frac{11}{11}\mid\frac{12}{10}$. Total, 50.

Branchial formula, 12–11:—3 $\frac{10}{9} \mid \frac{10}{9}$, 3 $\frac{10}{9} \mid \frac{10}{10}$, 3 $\frac{10}{10} \mid \frac{10}{10}$, 1 $\frac{10}{10} \mid \frac{11}{9}$, 2 $\frac{10}{10} \mid \frac{10}{9}$, 2 $\frac{11}{10} \mid \frac{10}{10}$, 3 $\frac{11}{10} \mid \frac{11}{10}$. Total, 17.

Branchial formula, 12–12:—1 $\frac{9}{9} \mid \frac{9}{9}$, 1 $\frac{9}{9} \mid \frac{9}{10}$, 2 $\frac{9}{9} \mid \frac{10}{9}$, 16 $\frac{10}{9} \mid \frac{10}{9}$, 4 $\frac{10}{9} \mid \frac{10}{10}$, 1 $\frac{10}{9} \mid \frac{11}{10}$, 1 $\frac{10}{10} \mid \frac{10}{9}$, 3 $\frac{10}{9} \mid \frac{11}{9}$, 3 $\frac{11}{9} \mid \frac{10}{9}$, 23 $\frac{10}{10} \mid \frac{10}{10}$, 3 $\frac{10}{10} \mid \frac{11}{10}$, 4 $\frac{11}{10} \mid \frac{10}{10}$, 2 $\frac{11}{10} \mid \frac{10}{9}$, 1 $\frac{10}{10} \mid \frac{11}{10}$, 1 $\frac{10}{10} \mid \frac{11}{9}$, 2 $\frac{11}{9} \mid \frac{10}{10}$, 2 $\frac{11}{10} \mid \frac{10}{9}$, 13 $\frac{11}{10} \mid \frac{11}{10}$, 2 $\frac{11}{10} \mid \frac{11}{9}$, 1 $\frac{11}{10} \mid \frac{10}{10}$, 1 $\frac{11}{10} \mid \frac{11}{11}$, 1 $\frac{12}{9} \mid \frac{12}{9}$. Total, 88.

Branchial formula, 12–13:—1 $\frac{11}{9} \mid \frac{10}{10}$.

Branchial formula, 13–12:—1 $\frac{11}{9} \mid \frac{10}{10}$, 1 $\frac{11}{10} \mid \frac{11}{10}$.

Branchial formula, 13–13:—1 $\frac{10}{9} \mid \frac{10}{9}$, 1 $\frac{10}{9} \mid \frac{10}{10}$, 1 $\frac{10}{10} \mid \frac{10}{10}$. Total, 3.

The following table is a summary of all the variations found in the 162 specimens observed.

NUMBER OF INDIVIDUALS.	DENTAL FORMULA.	NUMBER OF INDIVIDUALS.	DENTAL FORMULA.
2	$\frac{9}{9} \mid \frac{9}{9}$	6	$\frac{11}{10} \mid \frac{10}{9}$
1	$\frac{9}{9} \mid \frac{9}{10}$	2	$\frac{11}{10} \mid \frac{11}{9}$
2	$\frac{9}{9} \mid \frac{10}{9}$	2	$\frac{10}{10} \mid \frac{11}{9}$
1	$\frac{10}{9} \mid \frac{10}{8}$	1	$\frac{10}{9} \mid \frac{11}{10}$
31	$\frac{10}{9} \mid \frac{10}{9}$	24	$\frac{11}{10} \mid \frac{11}{10}$
10	$\frac{10}{9} \mid \frac{10}{10}$	9	$\frac{11}{10} \mid \frac{10}{10}$
4	$\frac{10}{10} \mid \frac{10}{9}$	9	$\frac{10}{10} \mid \frac{11}{10}$
2	$\frac{10}{10} \mid \frac{9}{10}$	1	$\frac{10}{10} \mid \frac{10}{11}$
5	$\frac{10}{9} \mid \frac{11}{9}$	1	$\frac{11}{10} \mid \frac{11}{11}$
4	$\frac{11}{9} \mid \frac{10}{9}$	1	$\frac{11}{10} \mid \frac{12}{9}$
1	$\frac{11}{9} \mid \frac{11}{8}$	1	$\frac{11}{10} \mid \frac{12}{10}$
1	$\frac{11}{9} \mid \frac{11}{9}$	1	$\frac{11}{11} \mid \frac{10}{10}$
1	$\frac{10}{9} \mid \frac{11}{10}$	1	$\frac{11}{11} \mid \frac{12}{10}$
6	$\frac{11}{9} \mid \frac{10}{10}$	1	$\frac{12}{9} \mid \frac{12}{9}$
31	$\frac{10}{10} \mid \frac{10}{10}$		
	Total number	162	

From a comparison of the above dental formulae, including in all 248 specimens, we conclude:

(1) That there is an exceedingly great variation in the number of the teeth, even more striking than in the case of the gills. Thus these two characters (the number of teeth and gills), the only two "constant" characters which Johannes Müller could find upon which to base his classification, are both proven to be *extremely variable*.

(2) In a large number of cases the two sides of the dental plate are not symmetrical with regard to the number of teeth. It is to be feared that the dental formulae given in systematic accounts of Bdellostoma are, in many cases, based upon counts of *one side only* of the dental plate.

(3) There is no constant relation between the number of teeth and the number of gills. If there is any difference at all worthy of note, the individuals with the larger number of gills have a smaller proportion of teeth than might be expected.

(4) There is no constant relation between the number of teeth and the size or sex of the individual. The size and sex, though not given in the above tables, were noted in every case. While we should naturally expect that the larger individuals would have a larger number of teeth, this is usually not the case. In a 23-inch specimen, for example, which is considerably above the average size, the dental formula was $\frac{8}{9} \mid \frac{10}{9}$.

(5) The outer rows of teeth have in a majority of cases a greater number of teeth than the inner. In 312 cases the teeth of the outer row were more numerous than those of the corresponding inner row. In 178 cases they were equal. In only 6 cases had the inner rows a greater number of teeth.

(6) The dental formulae occurring oftenest are: $\frac{10}{9} \mid \frac{10}{9}$ (45), $\frac{10}{10} \mid \frac{10}{10}$ (38), $\frac{11}{10} \mid \frac{11}{10}$ (32), $\frac{11}{10} \mid \frac{10}{10}$ (22). It is evident that we cannot speak of any one "typical" or predominant formula. More than half the rows of teeth number 10 however, and in nearly half the cases the corresponding outer and inner row each contains 10 teeth. The number 9 is given next in frequency, but occurs less than half as often as 10. More than 95% of the rows include either 9, 10, or 11 teeth.

The Chilian specimens seem to average a larger number of

teeth, for Girard counted in his type specimens with 14 gills $\frac{12}{12} \mid \frac{12}{12}$, while Putnam found $\frac{18}{12} \mid \frac{18}{12}$ or $\frac{12}{11} \mid \frac{12}{11}$ in the material he studied from Talcahuano Bay (Hassler expedition), reported as having 10 gills.

Lacépède's example from Chili had the very unusual dental formula of $\frac{11}{7} \mid \frac{11}{7}$.

A critical histological study of the dental structures of Bdellostoma is reserved for a separate paper. But it may be mentioned that the hollow bases of the corneous teeth rest upon soft dental papillae, which are fused together below into a bar extending the entire length of the row of teeth. These papillae are epidermal in origin, and the teeth are simply cornified sheaths of the epidermal elevations upon the dental plate. They are easily sectioned when imbedded in celloidin, and show no traces of dentine, enamel, bone, or calcareous matter of any kind.

March, 1898.

(*To be continued.*)

SYNONYMOUS TERMS FOR SKELETAL PARTS.

Ayers and Jackson.	Johannes Müller.
Notochord	Gallertsäule.
Cellular sheath of same	Innere Schicht.
Fibrous core	Faser-Faden.
Notochordal sheath	Innere Scheide der Gallertsäule.
Skeletogenous layer, elastica externa	Aeussere Scheide der Gallertsäule.
Neural tube	Rückenmarksrohr.
Auditory capsule	Gehörkapsel.
Parachordals	Knöcherne Basis cranii.
Trabeculae	Flügelfortsätze derselben.
Hypophysial plate	Gaumenplatte.
Subnasal cartilage	Knöcherne Stütze der Schnautze.
Transverse labial cartilage	Innerknorpel.
Lateral labial cartilage	Knorpel-Fortsatz am vordern Ende des Zungenbeins.
Nasal tube	Nasenrohr.
Olfactory capsule	Nasenkapsel.
Cranium	Gehirnkapsel.
Tentacular cartilages	Mundknorpel.
Dental plate	Zunge.
Teeth	Zähne.
Anterior segment of basal plate	Vordere Reihe der Zungenbein-Knochenstücke.
Middle segment of basal plate	Hintere Reihe der Zungenbein-Knochenstücke.
Posterior segment of basal plate	Knorpeliger Kiel des Zungenbeins.
Palatine bars	Gaumenleisten.
Cornual cartilages	Knorpel-Fortsatz am vorderen Ende der Gaumenleiste.
Pterygo-quadrate	Unterer Fortsatz der Gaumenleiste.
Hyoid arch	Verbindung der Fortsätze mit der Gehörkapsel.
Superior lateral cartilage	Oberer Fortsatz des Schlundkorbes.
Inferior lateral cartilage	Unterer Fortsatz des Schlundkorbes.
First branchial arch	Grosses Horn des Zungenbeins.
Second branchial bar	Kleines Horn des Zungenbeins.
External lateral bar	Hauptstück des Schlundsegels.
Internal lateral bar	Mittel-Riemen des Schlundsegels.
Suprapharyngeal plate	(In part-) Aufsteigende Fortsätze des Mittelriemens.

EXPLANATION OF PLATE XXII.

FIG. 1. A cross-section of the notochord, spinal cord, and sheaths of Bdellostoma a short distance behind the cranial region (× 10, camera lucida outlines).

FIG. 2. A cross-section of the notochord, spinal cord, and sheaths of Bdellostoma in the posterior gill region (× 10, camera lucida outlines).

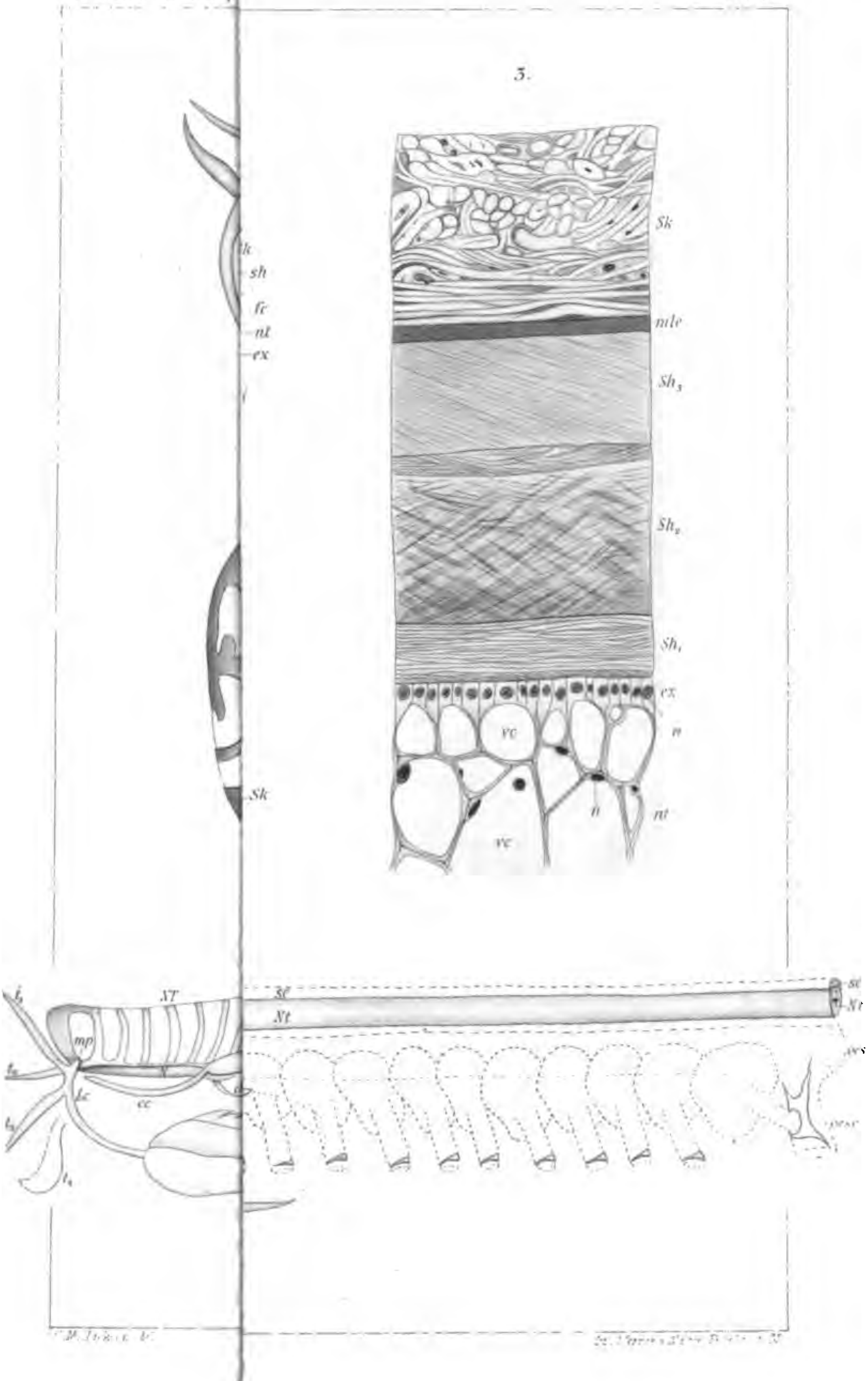
FIG. 3. Section of the notochord and its envelope.

FIG. 4. A cross-section of the cranium of Bdellostoma through the region of the auditory capsules (× 20, camera lucida outlines).

FIG. 5. Dorsal view of the skull of Bdellostoma (× 2).

FIG. 6. The skull and the skeleton of the pharyngeal region of Bdellostoma, lateral view. The roof of the spinal canal, the oesophagus, the gills and gill passages, and the retractor mandibuli muscle are outlined with dotted lines (× 2).

A. = auditory capsule.
a. = anterior connecting process.
B. = anterior segment of the basal plate.
B.' = middle segment of the basal plate.
B.'' = posterior segment of the basal plate.
b. = superior lateral cartilage.
b.' = inferior lateral cartilage.
$br._1$ = 1st "branchial" arch.
$br._2$ = 2d "branchial" arch.
Br. = brain.
Cr. = cranium.
c.c. = cornual cartilages.
c.s. = superior chondroidal bar.
c.i. = inferior chondroidal bar.
D. = dental plate.
d.t. = median dorsal tooth.
ex. = external cellular layer.
F. = "fatty" tissue of the neural tube.
F.' = similar layer within the cranium.
F.c. = fibrous core.
F.s.i. = fascia superficialis interna.
g.b. = gill bar.
Hy. = hyoid arch.
H.p. = hypophysial plate.
i.m.s. = intermuscular septum.
L.c. = lateral labial cartilage.
L.p. = lateral (ethmoidal) plate.
m.l.e. = membrana limitans externa.
m.d.s. = median dorsal septum.
m. = median connecting process.
m.p. = internal process of lateral labial cartilage.
Nt. = notochord.
n. = nucleus.
n. sh. = notochordal sheath.
N. = subnasal bar.
N.T. = nasal tube.
Oes. = oesophagus.
oes.c. = oesophago-cutaneous duct.
O.C. = olfactory capsule.
P.Q. = pterygo-quadrate.
Pl. = palatine bar.
p.c. = parachordal cartilage.
S. = supra-pharyngeal plate.
sc. = neural tube.
s.b. = basal process.
sk. = skeletogenous layer.
$Sh._1$ = internal layer of notochordal sheath.
$Sh._2$ = middle layer of notochordal sheath.
$Sh._3$ = external layer of notochordal sheath.
Sp. = spinal cord.
$t._1$, $t._2$, $t._3$, $t._4$ = 1st, 2d, 3d, 4th tentacular cartilages.
Tr. = main bar of the trabecula.
tr. = anterior horn of the same.
t. = tendon of retractor mandibuli muscle.
vc. = vacuole.
V. = external lateral velar bar.
V.' = internal lateral velar bar.
1, 2, 3, 4 = fenestrae of skull.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EXPLANATION OF PLATE XXIII.

FIG. 7. A dorsal view of the skull of Bdellostoma, cranium, olfactory capsule and nasal tube removed (× 2½).

FIG. 8. The basal plate of Bdellostoma, ventral view (× 1).

FIG. 9. A dorsal view of the basal plate of Bdellostoma (× 1).

FIG. 10. Dorsal view of the teeth and the dental plate of Bdellostoma (× 2).

FIG. 11. The dental plate of Bdellostoma, ventral view (× 2).

FIG. 12. A gill bar of Bdellostoma, stretched out (× 8).

FIG. 13. The cartilage of the oesophago-cutaneous duct of Bdellostoma (× 4).

FIG. 14. The skeleton of the posterior region of Bdellostoma (× 1).

FIG. 15. A cross-section of the tail of Bdellostoma, taken just in front of *r*, Fig. 14. Dorsal and ventral portion of section not shown (× 10).

A.i. = internal bars of anterior segment.
A.e. = external bars of anterior segment.
a.a. = lateral dental plate.
a.v. = cloacal cartilage.
a.b. = anterior transverse velar bar.
b.v. = blood vessel.
c.m. = palatine commissure.
c. = process of median ventral cartilage.
cn. = connective tissue.
D.m. = dermal muscle layer.
D.F. = dorsal fin.
e. = posterior external process of lateral plate.
ex.g.p. = external gill passage.
f. = auditory foramen.
f.r. = fin-ray.
g. = dorsal tendon groove.
h. = superior process of oesophago-cutaneous cartilage.
i. = posterior internal process of lateral plate.
K. = anterior process of hypophysial plate.
M.D. = median dorsal bar.
M.V. = median ventral bar.
Me. = median cartilage bar.
M.d. = median piece of dental plate.
My. = myotome.
oes.b. = the oesophago-cutaneous bar.
p.b. = posterior transverse velar bar.
p.a. = posterior arch of dental plate.
r. = anterior connecting process of lateral plate.
s. = sheath of fin-ray.
S.I. = epidermis.
T.I. = transverse labial cartilage.
tr. = anterior process of trabeculae.
V.F. = ventral fin.
v. = posterior connecting process of lateral plate.

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Morphology of the Myxinoidei

By

Howard Ayers and C. M. Jackson

ALTA PETIT.

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Morphology of the Myxinoidei

BY

HOWARD AYERS AND C. M. JACKSON

TWO PLATES.

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1900

Morphology of the Myxinoidei*

I. SKELETON AND MUSCULATURE

(CONTINUED)

C. REMARKS ON HOMOLOGIES

HOWARD AYERS AND C. M. JACKSON

*Contributions from the Morphological Laboratory of the University of Cincinnati

Ever since Müller described the anatomy of the head of Bdellostoma, comparative anatomists have constantly sought for the evidences of the relationship of the Marsipobranchii to the rest of the vertebrate stock.

We propose now to discuss the homologies of the head-skeleton of Bdellostoma—as a basis for the more general statement of the homologies between the Cyclostomes and Gnathostomes. Professor Huxley (1) announced several years ago that "There appears to be no sufficient foundation in the present state of knowledge for regarding the Marsipobranch skull as one which departs in any important respect from the general vertebrate type." A contrary view has more recently been published by Prof. Howes (2). We quote his statement in full for the reason that it represents the generally accepted view as to the position of the Maripobranchii, as shown by a study of their morphology. He says, (p. 141) "In view of the admitted importance of that (referring to the relations of the pituitary body) it testifies, to my mind, to an enormity in the gap between the Marsipobranchii and the remaining Vertebrata which even Balfour's conclusion that the former are the "remnants of a primitive group" and Haeckel's famous aphorism that they are further removed from the fishes than the fishes are from man, insufficiently expresses. It disposes of the attempts to prove that "connecting links" between the Marsipobranchii and the higher Vertebrata are known to us; and it is, to me, a question as to whether it does not warrant a greater than a class distinction, viz : the subdivision of the sub-kingdom Vertebrata into two lesser sub-kingdoms ; the one *Epicraniata* for the reception of the Marsipobranchii alone, the other, *Hypocraniata* for all the higher forms." It is not necessary to quote from other authors since these two views represent fairly well the two groups of anatomists—the one of which has affirmed that there exists between the Marsipobranchii and remaining Vertebrata so close a relationship that a general homology

of the parts may be established, the other of which maintains that there is no relation between these two groups of animals save that of their common vertebrate ancestry. Naturally, in attempting to solve this problem recourse is first had to the anatomy of the head. No one had previously established clearly the homologies of the cephalic skeleton, though Huxley very suggestively carried through a comparison of the Myxine and Petromyzon skulls with those of the higher vertebrates. He did not, however, work out his views in final shape, nor does his work show that he even approached a correct solution of the problem. All anatomists, Huxley included, have accepted Johannes Müller's view concerning the nature of the structure peculiar to the Marsipobranchii, viz: the so-called "tongue." And all have apparently overlooked the fact that were this a tongue or tongue-like organ, it would be a great anomaly in vertebrate anatomy; since none of the fishes, even the higher fishes, possess a tongue or even a tongue-like organ. The homology of this organ with the vertebrate tongue has never been discussed, nor do we know of any efforts to determine the true nature of this organ. In our efforts to establish the homology of the parts between the Marsipobranchii and the Gnathostomes, we were at once confronted with the so-called tongue, and after a careful investigation of the whole subject, we find that by determining the nature of this organ, we have solved the puzzle of Marsipobranch head morphology. Dr. Ayers began this investigation at the Hopkins Seaside Laboratory in the spring of 1892, and continued at the University of Missouri during the years 1896-98, where Mr. Jackson joined him in the work.

The importance of the so-called tongue of the head in the solution of the morphology became apparent to Dr. Ayers in 1892 while be was studying the motions of the organ in the living animal, and he then discovered that it was not a tongue, but probably the transformed jaw apparatus. The careful study of the details of the anatomy of Bdellostoma which we here present, conclusively prove, we think, this to be a fact.

As we have shown in a preceding section (3) the cranium in Bdellostoma remains in an exceedingly primitive stage of development throughout the entire life of the animal. It proves conclusively by its anatomical characters, that it is strictly homologous with the embryonic cranium of the higher vertebretes.

All of the variations which appear in the higher forms during their progress to the adult condition are added to the simple cranium as represented in the adult form of Bdellostoma.* In regard to the visceral head skeleton, we find adhesions and separations which complicate the problem to a considerable degree, and some of which, so far as we know do not occur among the Gnathostomata.

The space enclosed by the trabeculae and hypophysial plate (the hypophysial fontanelle) is occupied in Bdellostoma by the hypophysial tube, which therefore apparently perforates the floor of the cranium. It is more correct, however, to consider that this relation is due to an extension forward of the trabeculae to surround the hypophysial sac, since the latter is phylogemtically and ontogenetically the older structure. In Petromyzon and the higher fishes there is no communication between the hypophysial sac and the mouth or pharynx, and the hypophysial fontanelle is relatively smaller. The hypophysial plate seems to represent a depressed portion of the cranial floor, and is probably in part homologous, with the basisphenoid of higher forms. Its continuity with the trabeculae was overlooked by Müller. The lateral bars which in a dorsal view (after the nasal tube has been removed, fig. 8) seem to continue the trabeculae forward, and are evidently *palatine* cartilages.

The nasal tube† in Bdellostoma continues forward in the median line of the cranial axis to the anterior end of the head. The relation observed in Petromyzon, where the nasal tube is small and opens dorsally a considerable distance behind the anterior end of the head, is secondary. It is due to the enormous growth of the cartilages (excluding nasal tube) concerned in the development of the *suctorial* apparatus of Petromyzon. The lateral plates of the olfactory capsules are the homologues of the *ethmoids* of higher forms.

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* Even Petromyson shows a slightly higher stage of development, since in that form the *sides* as well as the base of the cranium are cartilaginous, while in Bdellostoma only the *base* is cartilaginous, the remainder of the cranium being membranous. The Auditory capsuls are also simpler in structure in Bdellostoma than in the Petromyzontes.

† The nasal tube of the Cyclostomes really represents nasal duct—hypophysial canal—since it forms a common exit for, and is formed by a common involution of, the nasal and hypophysial sacs.

Proceeding now to consider the ***prepalatine*** system of cartilages (Figs. 2, 3, including the subnasal, N, cornual, cc, labial TI, be, and tentacular cartilages 1, 2, 3, 4), we find that, although they present practically the same relations to the rest of the skull as in Petromyzon, their homologies have not hitherto been clearly recognized. For example, Johannes Müller (4) says: "Alles was daher bei Petromyzon vor dem Schädel und dem mit ihm verwachsenen harten Gaumen hat bei den Myxinoiden nichts ähnliches, und das sind der Lippenring, die zwei Seitenplatten, das vordere und das hintere Mundschild." A careful examination, however, reveals that each of these parts has a homologue in Myxinoids. Briefly stated, they are as follows:

Petromyzon.	*Bdellostoma.*
Annular Cartilage.	Labial and Tentacular Cartilages (in part).
Antero-lateral Cartilages.	4th Tentacular Cartilages.
Antero-dorsal Cartilage.	Subnasal Cartilage.
Postero-dorsal Cartilage.	Palatine Cartilages.
Postero-lateral Cartilages.	Cornual Cartilages.

This group of cartilages corresponds to the annular ring of Amphioxus and to the extremely variable group of labial cartilages in the higher forms.

According to previous authors, the jaw apparatus of the Marsipobranchii is entirely wanting or has suffered such regressive changes as to nearly obliterate it. A careful investigation of the skulls of Bdellostoma, Myxine, Petromyzon and Ammocoetes, however, discloses the fact that the ***entire mandibular arch is present***, although the relations of the several parts have been much altered from the usual gnathostome condition. The skeleton of the so-called "tongue" of the Marsipobranchii, with its paired, bilaterally symmetrical dentigerous plates (Figs. I, Y, D) is in reality the ***homologue of the lower jaw***, i. e., the Meckelian cartilages, of the usual gnathostome form. The huge club-shaped "tongue" muscle is made up of the muscles belonging to this arch. They have been, in Bdellostoma, entirely separated from their primitive attachment to the palato-quadrates, and have been translated to their present position in a manner which will be made clear in a subsequent paper. In Petromyzon, the original attachments are still closely retained. The dental plate of

Bdellostoma is homologous with the two pairs of "accessory lingual" dentigerous cartilages of Petromyzon.

The *upper portion* of the mandibular arch, i. e., the palato-quadrate portion, has been generally recognized by Huxley, Parker, Fürbringer and others. As in the typical gnathostome condition, it forms the subocular arch (Fig. 1, PQ), and extends cephalad and caudad. The anterior prolongation, P 1, forms the palatine bar, as already described, while the posterior forms a commissure connecting with the hyoid arch. Since the palato-quadrate is fused superiorly with the base of the cranium, the Marsipobranch skull belongs to Huxley's autostylic type. In Petromyzon the subocular arch bears a process which Parker (5) calls the antero-lateral process of the subocular arch, but which we consider to be strictly homologous with the quadrate of the higher forms. The same process, reduced in size, is found in Bdellostoma forsteri, and occasionally in Bdellostoma dombeyi.

The free end of this process probably marks the point of primitive articulation of the (now detached) Meckelian cartilages.

The muscles of the "tongue" are innervated by fibus from the tregeminus nerve—a fact recognized long ago by Müller and more recently by Fürbringer (6). This fact alone ought to demonstrate the absurdity of attempting to homologize the structure in question with a tongue. On the other hand, it clearly indicates its true nature as a mandibular apparatus.

The cause which led to the separation of the Meckelian cartilages (dental plate) from the palato-pterygo-quadrate portion of the arch was doubtless the acquisition of the "rasping" habit in feeding, especially in situations which prevented the free motion of the jaw in the dorso-ventral direction, (as, for example, when burrowing *into* a carcass). With the development of motion of the lower jaw in the fore-and-aft direction, the connection of the Meckelian cartilages (dental plate) with the quadrate was loosened, and finally entirely separated. The separation of the Meckelian cartilages, and especially of the muscles from their original connection with the palato-quadrate has taken place to a much greater extent in Bdellostoma than in Petromyzon. In the latter, the muscle still retains in part its original attachment. Modifications and migrations of the mandibular arch are not uncommon among the lower Vertebrata. In many forms (e. g. Scyllium) the entire arch is loosely connected

with the cranium by ligaments. In the sturgeon the arch has lost all direct connection with the cranium, except through the hyo-mandibular bars. A striking illustration of transformation is seen in the formation of the *malleus* and *incus*, which are cut off from the proximal end of Meckel's cartilage, removed from their original location, and enclosed in a special chamber where they serve an entirely new function. With these examples in mind we can readily comprehend the state of affairs just described in the Marsipobranchii, where, notwithstanding their transposition, the parts still subserve their original function.

Immediately behind the palato-quadrate cartilage, a second bar extends from the auditory capsule, as previously described. (Figs. 1, 2, 3, Hy). This is the upper portion of the hyoid arch. In Myxinoids, this arch is connected to the palato-quadrate by two processes; in Petromyzon (Fig. 6) by only one. The ventral portion of the hyoid arch, like the mandibular, has become detached from its primitive position. The basal portion of the hyoid arch in Bdellostoma forms the anterior segment of the basal plate. In Petromyzon, it is apparently represented by the "median ventral cartilage" of Parker.

The basal plate (Figs. 5 and 1) of Bdellostoma is a structure almost as interesting as the "tongue" itself (for which it forms a support). As previously described by us, it is made up of three segments. Of these, the posterior (B″) is composed, not of true cartilage, but of a chondroidal tissue, and is certainly not to be considered as homologous with any part of the visceral arches. It is merely a condensation of the tendinous tissue in the median ventral raphe of the *constrictor musculi mandibuli*. The anterior segment (B) of the basal plate evidently represents the *basi hyoids* and copulae. The middle segment (B′) as shown by its connection with the two branchial bars (Fig. 1, br., br.2) is probably similarly formed by a fusion of the ventral portion of the first and second branchial arches (third and fourth *visceral* arches.)

In Petromyzon, the middle segment of the basal plate is wanting. The large "lingual cartilage" is equivalent to the posterior segment in Bdellostoma, and the "median ventral cartilage" to the anterior segment.

As to the visceral skeleton behind the hyoid arch, we have already pointed out that the two prominent lateral cartilagenous

strips (Figs. 2, 3, 5, br. 1, br. 2) represent the 3d and 4th visceral arches (1st and 2d branchial bars) whose ventral portions have fused together to form the middle segment of the basal plate.

It is also altogether probable that the complicated velar framework of cartilages (Figs. 1 and 3, V, V', ab, pb, etc.) represent the skeleton of a set of metamorphosed branchial arches. In this connection it is important to remember that, as Price (7) has shown, several of the most anterior branchial clefts *appear transiently* in the embryo, and soon disappear. It is to these branchial clefts that the metamorphosed branchial arches found in Bdellostoma evidently belong. The degeneration of the anterior branchial sacs is undoubtedly due to the enormous growth of the club-shaped "tongue" muscle, which in pushing backward necessarily encroaches upon the branchial territory. As the club-shaped muscle is much less developed in Petromyzon, the latter form has not undergone so much modification in the anterior branchial region.

In the posterior branchial region we find a set of cartilages, now described for the first time, which represent the *branchial arches* (V. preceding section of this paper). They are comparatively small in size, but lie imbedded in the walls of the external branchial passages (i. e. gill clefts), and undoubtedly are the representatives of the complicated "branchial basket" found in Petromyzon (fig. 6). The relation becomes evident when we examine the skeleton of a young Petromyzon embryo (fig. 7). The figure shows that at an early stage the branchial basket of P. appears as a series of slender bars, each partially enclosing the corresponding gill slit, and connected only by a ventral connecting strip. With the exception of the latter the relations are identical with those found in adult Bdellostoma. It is also important to note that the gill bar corresponding to the oesophago-cutaneous duct (which is really a modified gill slit) extends along the duct *to the wall of the pharynx*, upon which it often expands to a greater or less degree. It is evident, therefore, that no distinction between the Cyclostome branchial cartilages (as "*extra branchials*") and those of the remaining vertebrates can properly be drawn.

Our most important conclusions concerning homologies of the Myxinoid skeleton may be summarized as follows:

1. The discovery of the series of rudimentary gill bars in

Bdellostoma, and the true interpretation of the circumoral and "lingual" regions in Bdellostoma and Petromyzon enables us to establish completely the homologies within the Marsipobranch class.

2. The discovery that the so-called "tongue" of the Marsipobranchii is in reality the detached lower jaw solves the puzzle of Myxinoid morphology, and makes clear their general relation to the remaining vertebrates. They are *true Gnathostomes*, forming a primitive group which probably sprang from the common ancestry before the acquisition of paired appendages by the vertebrate type. The relation of the Marsipobranchii to the vertebrate stock is shown in the diagram on the opposite page.

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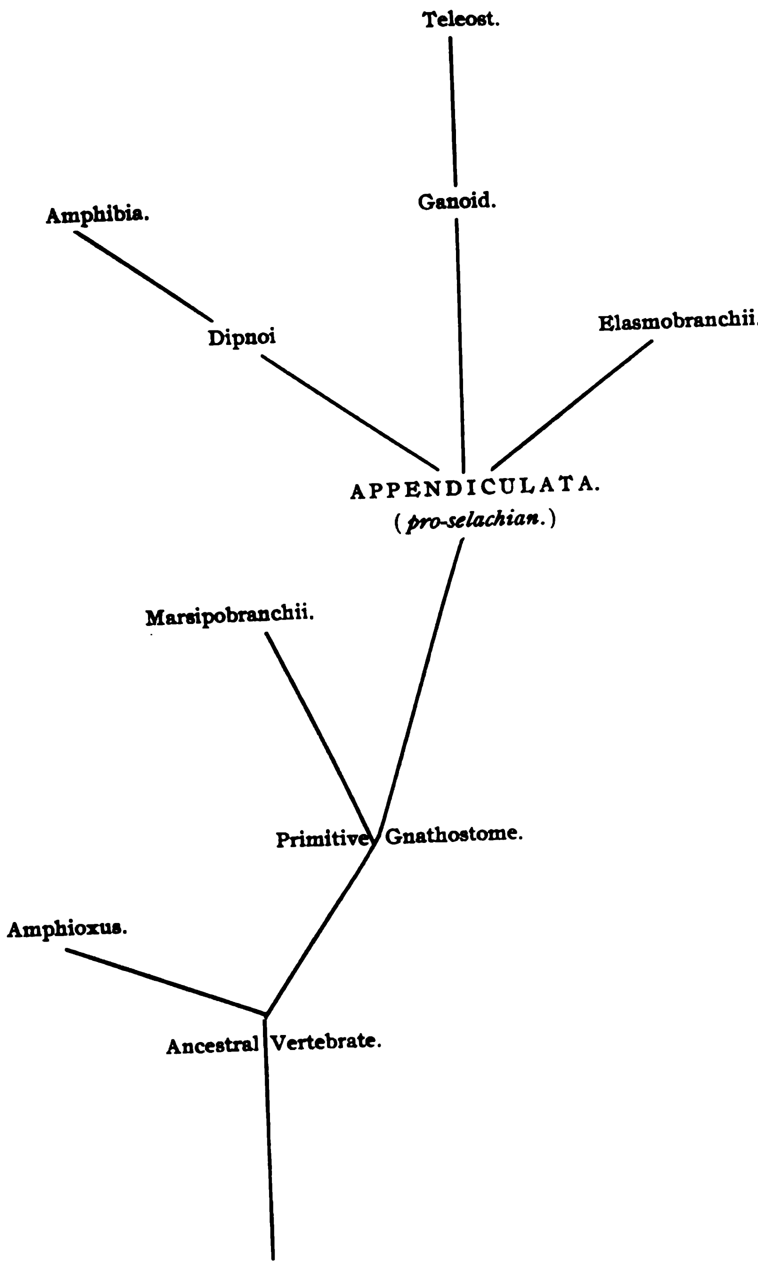
Teleost.
Ganoid.
Amphibia.
Dipnoi
Elasmobranchii.
APPENDICULATA.
(*pro-selachian.*)
Marsipobranchii.
Primitive Gnathostome.
Amphioxus.
Ancestral Vertebrate.

EXPLANATION OF FIGURES 1, 2, 3, 4, PLATE I, AND FIG. 5, PLATE II.

A, auditory capsule.

a, anterior connecting process.

Ae, external bars of anterior segment.

Ai, internal bars of anterior segment.

ab, anterior transverse velar bar.

B, anterior segment of basal plate.

B′, middle segment of basal plate.

B″ posterior segment of basal plate.

br., br., 1st and 2d branchial arches.

cm, palatine commissure.

Cr, cranium.

cc, cornual cartilages.

D, dental plate.

Hy, hyoid arch.

H.p., hypophysial plate.

L.c., lateral labial cartilage.

Nt, notochord.

O.C., olfactory capsule.

p.b., posterior transverse velar bar.

PI., palatine bar.

P.Q., pterygo-quadrate.

t, tendon of retractor mandibuli.

Tr, trabecula.

T.I., transverse labial cartilage.

V,V′, external and internal lateral velar bars.

Fig. 1.

Fig. 2.

Fig. 3.

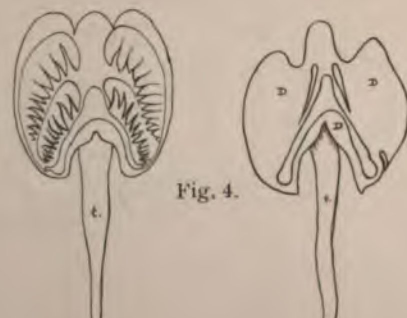

Fig. 4.

a *b*

H. AYERS, *del.*

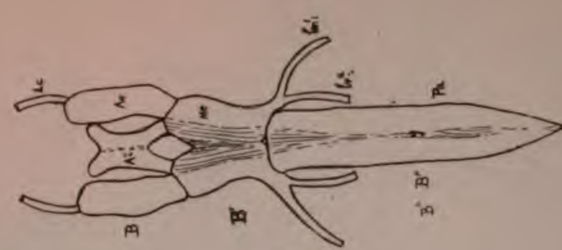

Fig. 5.

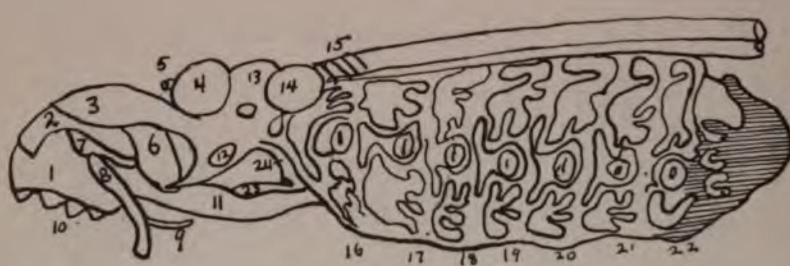

Fig. 6.

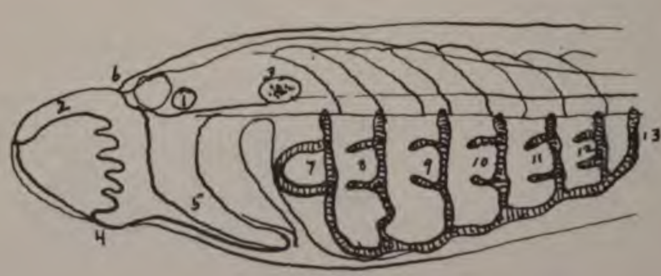

Fig. 7.

EXPLANATION OF FIGURE 6, PLATE II.

ADULT PETROMYZON SKULL (lateral views).

		Homologous with Bdellostoma.
1.	**Annular ring ("Lippenring")**	**Labial and tentacular cartilages.**
2.	**Antero-dorsal Cartilage.**	**Sub-nasal cartilage.**
3.	**Postero-dorsal "**	**Palatine cartilage.**
4.	**Nasal capsule**	**Olfactory capsule.**
5.	**Nasal tube**	**Nasal tube.**
6.	**Postero-lateral cartilages**	**Cornual cartilages.**
7.	**Antero-lateral cartilages**	**Fourth tentacular cartilages.**
8.	**Styliform cartilages**	**Tentacular cartilages.**
9.	**Medium ventral cartilage**	**Anterior segment of basal plate.**
10.	**Labial teeth**	**Labial teeth.**
11.	**Lingual cartilage**	**Third segment of basal plate.**
12.	**Sub-ocular arch**	**Sub-ocular arch.**
13.	**Cranium**	**Cranium.**
14.	**Auditory capsule**	**Auditory capsule.**
15.	**Neural arches**	**Neural arches where present.**
16-22.	**Branchial bars**	**Branchial bars.**
23.	**"Cornual" cartilage**	**Hyoid arch.**
24.	**Styloid process**	**Hyoid arch.**

EXPLANATION OF FIGURE 7, PLATE II.

EARLY EMBRYO OF PETROMYZON (after Schulze).

1, eye.

3, auditory capsule.

2, 4, annular cartilage.

5, styliform cartilage.

6, Nasal capsule.

7-13, branchial bars.

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The Placidus Commentary on Statius

BY

JOHN M. BURNAM, Ph. D.

Professor of Latin

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CINCINNATI, O.

The Placidus Commentary on Statius.

The poet Statius attained recognition as a classic almost in his own time, and as such, became the object of learned comment on the part of the school teachers and professors of rhetoric in, perhaps, the early centuries of the empire. At all events, there exists in a considerable number of manuscripts a body of glosses, scholia, etc., ascribed to a certain Lactantius or Luctatius Placidus. This commentary is assigned in the Teuffel-Schwabe History of Roman Literature to the fifth century, and the author is identified with the grammarian, glossator and scholiast of the same name, who has left us a series of notes on Cicero. The manuscripts, in most instances, identify him with the famous Christian writer Caelius Lactantius Firmianus.

Until quite recently, the vulgate text of these scholia was that of Lindenbrog, or as he Latinized his name, Tiliobroga; his Statius with the Placidus notes appeared at Paris in 1600, and was reprinted at Lyons in 1654. Lindenbrog depended for his text on manuscripts very much inferior to some now known, and very much like a Bruxellensis mentioned by Cumont, "Textes et Monuments figurés relatifs aux Mystères de Mithra," vol. II, p. 46. In 1898 the well-known Leipsic publishing house of B. G. Teubner sent out as the third volume of the works of Statius, "Lactantii Placidi qui dicitur Commentarios in Statii Thebaida et commentarium in Achilleida recensuit Ricardus Jahnke." J. had the use of the notes for just such an enterprise left by Kohlmann, and acknowledges the assistance of Klotz, Kelter, Vollmer and Usener. He gives as the manuscript foundation for his text the following codices:

Monacensis 19482 (M), Parisinus 8063 (Pa), Parisinus 8064 (Pb), Parisinus 10317 (Pc), Bambergensis M IV 11 (*Bamb.*), Casselanus Mscr. poet. fol. 8 (*Cassel.*), Gudianus 54 (*Gudian.*), and lastly, Mon-

acensis 6396 (*Mon.*) He divides all the existing manuscripts into two classes, those that have the commentary apart from the poet's text, and those that show that commentary in the margin and along with Statius himself. J., however, has actually used only four codices, viz.: M, Pa, Pb and *Mon.*, expressing the hope that he has laid the foundation on which others may build.

I propose to discuss, in a series of papers, some manuscripts mentioned by Jahnke, and some others that seem to be entirely unknown to the generality of scholars. I begin with Paris. 10317.

This codex was partly used by Kohlmann, "Neue Scholien zur Thebais des Statius, Posen 1873," a work which I regret not having seen; and again, in "Lactantii Placidi in Statii Thebaida, 3, 1-323 Commentarii, Emden, 1887." It has received treatment from C. Wotke also in "Eranos Vindobonensis 1893," who arrives at the conclusion that the manuscript has no value for the criticism of the poet's text; for a contrary opinion, vid. Jahnke, p. 8, and his article in the Philogus XXXII, p. 130 ss. For a good facsimile, vid. Chatelain, "La Paléographie des Classiques Latins" pl. CLXIII and his commentary.

This codex contains a number of notes, most of them long, and in the majority of cases historical or mythological in character; they have been only partially published in the articles above referred to. It is the purpose of the present paper to reproduce them, with the indication of their source or parallels, so far as these can be determined. Usually the text is conventionalized in spelling. Sometimes I have given the readings of the manuscript for the purposes of comparison. The syllable (Add.) preceding a note means that it is additional to what is found in L. or J. on the same passage.

While Chatelain has given a good description of this codex, a closer study of it has disclosed a few facts that he has not noticed. On account of the heading, he had guessed that it might owe its origin to the scriptorium of Epternach, or Echternach, a convent founded by English monks in the Luxemburg country in the year 698. This attribution is amply confirmed by the following marginal glosses to the Thebaid, none of which (so far as I know) have as yet found their way into print:

1. Th. II, 553 (indagine) haga.
2. III, 233, turba id est druuo.
3. III, 511 (striges), hexa.
4. VIII, 617 (pandionie uolucres), sualououn.

Let the Germanist determine the particular dialect represented by these words; in any event, they point to North German territory, or its immediate neighborhood.

An investigation of the errors and confusions which occur in this manuscript shows that the scribe had before him an archetype in the Spanish or Visigothic hand; that the writing was more or less cursive, and employed some of the usual abbreviations. Let the reader observe the following points:

1. a and u are constantly confused; e. g., II, 715, tautela is for tutela; III, 16, natare stands for naturae; V, 432, alterius for ulterius. These are only a few among many instances which might be cited, and they show that a was open—one of the leading characteristics of the Spanish style.

2. u (v) occurs for b. This indicates either a very early archetype or one of Visigothic character. This confusion is still one of the peculiarities of Spanish pronunciation.

3. Spanus and its derivatives are regularly used for hispanus, &c.

4. Two letters that always cause trouble in the Visigothic hand are p and q, so great is their resemblance. Cf. IX, 475, spqualore. The long Isidore extract, VI, 576, has P for quod no less than nine times. Here the scribe had before him a ꝗ which he mistook for the current pro sign.

5. t and d exchange places in IX, 474, where we find natandes for natantes, and in XI, 571, the scribe has written artanto instead of artando. This error is very easy when the manuscript is of the eighth century and the writing is cursive Visigothic. Vid. Merino Escuela Paleographica 3, no. 3.

6. At VI, 476, eto appears for eo, and 7. at II, 518, utrius for verius. Here again we have blunders easily made in reading such an archetype as we have supposed.

8. uagiantur, VI, 642, for variantur is a probable error, when the writing is an early cursive.

9. When the scribe wrote curstumina for Crustumina, VI, 576, and conpersa for compressa, X, 850, he reproduced two examples of the well known Spanish metathesis, which is still current in the Iberian peninsula.

10. In III, 16, nt occurs at the end of a word where we must correct to rit; conversely, I, 478 of the same book, rt is there for nt. These mistakes are due to the interlacings of the cursive style.

11. The same explanation holds good for such a blunder as in XII, 434, where ex is read for et.

Here is a mass of evidence sufficient to prove the statement that the archetype must have been in a more or less cursive Spanish hand; that the hand employed abbreviations, too, is shown by another set of mistakes—e. g., unde is never correctly written, appearing as unus or unum. The copyist was deceived by seeing un with the upper bar of contraction, a sign which he wrongly interpreted. The above-mentioned confusion of pro and quod looks in the same direction. In VIII, 869, homines stands for hoc est, the cause being another abbreviation.

The occurrence of lacunae at short distances from each other makes it possible that the Placidus was in short lines, or perhaps in the margin, as in the copy under discussion.

If we now ask whether the age of the archetype can be fixed with any degree of certainty, it seems that the evidence is sufficient to justify the conclusion that it was not later than the end of the eighth century. For after that time the Spanish hand becomes too regular to pass for cursive. Before that epoch, we could hardly expect ordinary manuscripts to show any contractions. With this much determined, I think we have a better basis for the criticism of the Placidus scholia than before.

Whence came these notes? The ultimate sources were chiefly Cicero, Varro and Verrius Flaccus, but they were not immediately known to the compiler, who has drawn on collections at second-hand, like those of Pliny, Solinus, Servius, Fulgentius and Isidore. In a very large number of passages this text coincides with that of the Vatican Mythographers.

Th. I, 64. Ideo dicitur trifida vel quia munita est tribus ordinibus murorum vel quia in tria diducitur promunctoria, vel etiam quia in fine eius promunctorii sit sita.

275. Oenomaus...Elidis rex parvam habuit filiam nomine Hippodamiam, qui etiam habuit equos celocissimos utpote ventorum filios; qui procos filiae suae sub hac condicione vocavit ad curule certamen ut aut victus traderet filiam aut victos necaret. (Serv. Georg. III, 7; Myth. Vat. I, 21, 204; II, 146; Plac. Th. II, 166, 185.)

279. Id est mentitur se habere tui corporis bustum. Ideo enim Cretenses dicunt se habere, quia ibi natus est et nutritus; cuius fabula talis est. Saturnus postquam a Themide oracula suscepit se posse a regno pelli, natos ex Rhea uxore devorabat; quae natu laetata nymphis commendavit in monte Dictaeo, ubi apes eum aluerunt et adhibentes (l. adhibiti) sunt Curetes et Corybantes qui tinnitu aeris prohibebant audiri vagitum. Ideo autem fingitur illic esse nutritus ut Sallustius (Hist. Frag. III, 14 M.) dicit quia primos constat contentos religione deorum. De Creta multi dubitant in quo mari sit sita. Nam apud chorographos legimus quaeque in quo mare: ita Sardinia in Africano, Delos in Aegaeo: de Creta enim dubitant. Nam in parte mare lilibeum (l. Lybium) in parte Aegyptium, in parte Achaicum, in parte Ionium respicit. Ergo in medio ponto est. (Serv. Aen. III. 104; Plac. Ach. I. 387; Myth. Vat. I. 104; II. 16; III, 510.)

286. Id est tibi caros ut Vergilius (Aen. I, 24). "Pro caris gesserat Argis." Notandum est quod Argos numero singulari generis neutri est ut Horatius (Od. I. 7, 9) "Aptum dicet equis ditesque Mycenas." In plurali masculini, ut hi Argi. Ceterum derivatio nominis Argivos facit non Argos. (Serv. Aen. I. 24; cf. Prob. Cath. 22, 13 K.)

338. *Rorem ferente.* Nam omnis ros omnisque umor in corpore lunae constare videtur. Ideoque secundum incrementum vel diminutionem lunae umores in animalibus, vel etiam in arboribus mutari videmus. Nam hi plenius rore perfundi videntur qui sub corpore lunae caelo sereno indegent (l. indigent). (Cf. Pithoei Catalecta ap. Forc. sub rorifluo.)

Biga autem dicitur duorum equorum quasi biiuga. Et notandum poetica licentia nomen singulariter proferri; quod pluraliter secundum artem fieri debebat. (Add. alia manus, sicut Donatus dicit in secunda editione). (Cf. Serv. Aen. II, 272; Pomp. 167, 20-21 K.; Beda Orth. 267, 21-22 K.)

343. Proprie iubar lucifer dicitur quod iubas lucis effundat,

unde etiam quicquid splendit iubar dicitur (ut) argenti, gemmarum. Est autem lucifer interdum Iovis, plerumque Veneris stella et facit hoc iubar huius iubaris. (Serv. Aen. IV. 130; Is. Or. III. 71, 18; cf. Varro L. L. VII. 76; Fest. Paul. 100; Prob. Cath. 11, 34 K.)

477. Prima Furiarum Allecto. Allecto Graece impausibilis dicitur, Tesiphone quasi τούτων φωνή id est istarum vox, Magaera autem quasi μεγάλη ἔρις id est magna contentio. (Fulg. Myth. I, 6; Myth. Vat. I, 109; II, 12; III, 6, 23.)

520. Tangit Romanam superfluitatem, qui, ut Cato ait, in atrio et in duobus epulabantur ferculis. Iuvenal. (I, 94-95) "Quis fercula septem secreto cenavit avus?" Unde quia honoratiores erant, custodes liminum adhibebant. Verg. (Aen. IX, 647-8) "Qui Dardanio Anchisae armiger ante fuit, fidusque ad limina custos." Ibi etiam et culina erat, unde atrium dicitur quasi atrum. (Serv. Aen. I. 726; cf. Is. Or. XV, 3, 4.)

Teretes vero rotundas. Nam teres proprie dicitur rotundum aliquid cum longitudine, ut columna cylindrum. (Cf. Fest. p. 363; Serv. Buc. VIII, 16; Aen. VI, 207; Is. Or. XV, 2, 16.)

521. A lychno lucerna dicta est, unde brevis est *lu*. Iuvenal. (l. Pers. V. 181) "Disposite pinguem nebulam vomuere lucernae." (Serv. Aen. I, 726; Is. Or. XX, 10, 2.)

526. Solio, scilicet regali cathedra. Est autem sedes ex solido ligno facta ad tutelam regii corporis facta. Sane ebur eboris facit non eburis sicut murmur murmuris. Unde quia in principalitatis declinatione varietas invenitur, etiam derivatio varia est. Nam eburnus facit, ab eo quod est ebur: eburneus ab eo quod est eboris. Dicitur autem ebur a barro hoc est elefante. Ut Horatius (Epod. XII, 1) "Quid tibi vis mulier nigris dignissima barris?" (Serv. Aen. I, 506; Is. Or. XX, 11, 10; Diff. Verb. 524.)

562. Iuno rivali Latonae monstrum Pythonem misit, ob quem cum fugaret, ad insulam Delon pervenit atque ibi duos filios progenuit Dianam et Apollinem; quae statim Diana obstetrix matris fuit in illo Apollinis partu, qui Apollo accepto arcu et pharetra Pythonem occidit. Cuius Pythonis coria (l. corio) Apollinis altare apud Delon festis operiebatur diebus. (Cf. Hyg. Fab. 53, 140; Serv. Aen. III, 73; Plac. Th. IV, 795, V. 533, Ach. I, 206; Myth. Vat. I, 13, 37, 113; II. 17, 19; III. 8, 1, 3-5.)

643. (Add.) Est autem ager vicinus Troiae plenus thymbra, in quo eius templum est et nemus. Sane quia Graece thymbre (θύμβρη) facit, in derivatione diphthongon mutat ut Aethne Aethnaeus, Dirce Dircaeus. (Serv. Aen. III. 85.)

710. (Add.) Nam eius iecur vultur exedit quamvis Homerus (Od. XI. 576 ss.) dicat vicissim duos vultures sibi succedere. (Serv. Aen. VI. 595; Myth. Vat. I. 13, II. 104, 105.) Declinatur vero Tityos Tityi, sicut Delos Deli. (Serv. Aen. VI. 595). Quod ideo fingitur quia Tityos est amor vel libido quae secundum physicos in iecore est, sicut risus in splene iracundia in felle: unde etiam exesus a vulture dicitur in poenam renasci quia libidini non est satis res semel peracta, sed revirescat. Horatius (Od. III. 4, 77) "Incontinentis nec Tityi iecur." (Serv. Aen. VI. 596; Is. Or. XI. 1, 125, 127; Myth. Vat. I. 13, II, 105, III, 6, 5; Macr. Comm. I. 10, 12.)

713. Phlegyas filius Martis habuit Coroniden filiam quam Apollo vitiavit, unde suscepit Aesculapium: quod pater dolens incendit Apollinis templum apud Delphos et eius sagittis est apud inferos trusus. (Serv. Aen. VI. 618; Myth. Vat. I. 115, 205; II, 22, 108, 128.)

II. 58. (Add.) Quando dixit *mediae*, ad naturam sideris respexit: nam inter caelum et terram, certis discretis spatiis, septem sidera pendent, quae vocantur errantia, cum errant nulla minus illis. Quorum summum Saturni sidus est, ideoque minimum videtur: inde, inferior Iovis est circulus; tertium Martis sidus igne ardens solis vicinitate. Infra solem ambit ingens sidus Veneris: proximum illi Mercurii circulo fertur. Sed omnium ammirationem vincit novissimum sidus terris familiarissimum Lunae. Ideo autem dixit *silentia mediae lunae*, quia Luna media est inter sidus Mercurii Terraeque positionem. (Plin. N. H. II. 12, 32, 34, 36, 39, 40.)

95. (Add.) Graecia enim quantum stupenda mendacio, tantum est admiranda commento. Tiresias enim in modum temporis posuerunt quasi *θέρους αἰών* id est mera perennitas. Ergo ex uno tempore quod masculinum est quod eodem clausa soliditas est germinum, dum coeuntia sibi affectu animalia viderit. Eaque virga id est aestu fervoris percusserit, in femineum sexum convertitur id est in aestatis fervorem. Ideo vero aestatem posuerunt in modum feminae, quod omnia patefacta eodem tempore suis emergunt folliculis; et quia duo concipiendi sunt tempora, veris et autumni, iterum conceptu prohibito ad pristinam redit imaginem. Autumnus enim ita omnia masculino corpore astringit quo constrictis arborum venis vitalis suctransennas commerciales stringens foliorum marculentam detundat calvitiem. Denique duobus dis id est duobus elementis arbiter quaeritur igni atque aeri de genere vario amoris certantibus: denique iustum profert iudicium. In fructificandis enim germinibus dupla aeri et igni materia suppetit. Aer enim et

maritat in glaebis et producit in foliis et gravidat in folliculis. Sol enim maturare tantum novit in granis. Nam ut hoc verum sit, caecatur etiam a Iunone, illa videlicet causa quod hiemps aeris nubilo caligante nigrescat. Iuppiter vero occultis vaporibus conceptionale et (l. ei) factum et futuri germinis ministrat id est praesentiam (l. praescientiam). (Fulg. Myth. II. 8; Myth. Vat. I. 16; II. 84; III. 4, 8.)

202. Metonymia est dum posuit deum pro ipsis nuptiis. Hymenaeus vero ut plerique dicunt deus nuptiarum; ut alii vero dicunt, quidam iuvenis fuit qui die nuptiarum ruina oppressus est. Unde expiationis causa nominatur in nuptiis: sed falsum est. Nam vitari magis debuit nomen extincti. Sed hoc magis habet veritatis; Hymenaeus quidam apud Athenas inter bella saevissima virgines liberavit, quam ob causam nubentes eius invocant numen quasi liberatoris virginitatis. Hinc etiam apud Romanos Talassio vocatur; cum enim in raptu Sabinarum plebeius quidam raptam pulcherrimam duceret, ne ei auferretur ab aliquo, Thalassionis eam ducis nobilis esse simulavit, cuius nomine fuit tuta virginitas. (Serv. Aen. IV. 99 D.; cf. Plac. Th. III. 283; Myth. Vat. I. 75; II. 219; III. 11, 13; Liv. I. 9, 12.)

237. Pallas aea—(rasura) id est Tritonia: Minerva et Athene eadem est. Secundum fabulam Pallas vocatur a Pallante gigante quem interfecisse fertur iuxta paludem Tritoniam; quod ideo fingitur quia sapientia interficit iacentem in luto miserabilis ignorantiae. Pallas autem nova interpretatur, sapientia enim nullam admittit vetustatem, nullum senium. Tritonia dicta quasi τρίτη νοία id est tertia notitia, scire videlicet deum animam creaturam corpoream. Minerva non mortalis. Μή Graece non, erva mortalis. Idem sonat et Athene: Athene quasi ἀθάνατος id est immortalis. (Fulg. Myth. II. 2; cf. Cic. N. D. III. 59; Fest. 220; Is. Or. VIII. 11, 71-75; Plac. Th. II. 715; Myth. Vat. I. 124; II. 115; III. 10, 1.)

249. Tria sunt fata Plutoni destinata: quarum prima Clotho, secunda Lachesis, tertia Atropos. Κλώθω enim Graece evocatio dicitur, Lachesis vero sors nuncupatur, Atropos quoque sine ordine dicitur; hac videlicet causa quod prima sit nativitatis evocatio, secunda vitae sors quemadmodum quis vivere possit, tertia mortis conditio, quae sine lege venit. Unde fingitur quod una colum teneat, altera filum trahit, tertia runpat. (Fulg. Myth. I. 7; Myth. Vat. I. 110; II. 14; III. 6, 3.)

483. (Lectissma) ad bellum id est in expeditionem bellicam

praeparationem. Nam hoc distat inter bellum et proelium; quod bellum est tempus omne quo vel praeparatur aliquid pugnae necessarium vel quo pugna geritur; proelium autem dicitur conflictus ipse bellorum. Unde bene dixit *laetissma bello corpora.* (Serv. Aen. VIII. 547; cf. Is. Diff. Verb. 547; Fronto Diff. 527, 27 K.; Diff. Serm. 285, 5 H.)

499. Callis est semita tenuior callo pedum praedurata: semita est semis via. Unde et semita dicta est actus dimidius, qua potest ire vehiculum; nam actus duos capit quoque euntium et venientium vehiculorum occursus. (Serv. Aen. IV. 405; cf. Is. Or. XV. 16, 9-10; Diff. Verb. 539.)

518. Inexpletam alvum, insaturabilem. Et proprie alvum dixit: nam alvus est qui cibum recipit et purgari solet. Sallustius (Hist. Frag. I. 52 M.) "Simulans sibi alvum purgari." Et vocatum alvum quod abluatur id est purgatur. Ex ipso enim sordes stercorum defluunt. Venter vero est qui acceptos cibos digerit apparet extrinsecus pertinetque a pectore ad inguinem, et dictus venter quod per totum corpus vitae alimenta transmittat. Uterum solae mulieres habent, in quo concipiant ad similitudinem calculi; tamen auctores pro utrolibet sexu ventrem plerumque ponunt. Vocatur autem uterus quod duplex sit et ab utraque in duas partes se dividat, quae in diversum fusae ac reflexae circumplicantur in modum cornu arietis vel quod interius impleatur fetu. Hinc et uter quod aliquid intrinsecus habuerit, menbra et viscera. (Serv. Aen. II. 20; Is. Or. XI. 1, 132-135; id. Diff. Verb. 38; Diff. Rer. 69.)

521. Dryades dicuntur nymphae silvarum. Illae vero quae cum silvis nascuntur et pereunt Hamadryades dicuntur; fontium vero nymphae dicuntur Napeae vel Naiades, maris Nereides, montium autem Oreades dicuntur. Et hoc dicit; nec Dryades nymphae neque Fauni gaudent ibi celebrare ludos cantilenasque suas in illius loci umbras efferre. (Serv. Buc. X. 62; Aen. I. 500; Is. Or. VIII. 11, 97; Plac. Th. IV. 255; Myth. Vat. II. 50; III. 5, 3.)

522 (Fauni) a fando dicuntur vel ἀπὸ τῆς φωνῆς, quod voce non signis ostendere viderentur futura paganis, a quibus consulebantur. (Serv. Aen. VII. 47, 81; Is. Or. VIII. 11, 87; Don. Eun. 1079; Myth. Vat. I. 227; II. 49.)

553. Indago autem est cum silvam venantium corona vallat ut ferae evadere non possint.

Sensus est: sicut prima vox, id est aliquis voce primitus clamans profert aut manifestat feras esse inclusas indagine, set (l. sic) illi

quo primi veniebant dicebant illum adesse seque iam habere vallatum Tydeum.

715. Minervam dicit quam gentiles deam Martiam esse dixerunt, quae alio nomine Pallas dicitur. Quae ideo de Iovis capite nata fingitur quia ingenium in cerebro positum est. Ideo armata quia est contra ignaros sapientia. Gorgonam etiam addunt in pectore quasi terroris imaginem; ita vir sapiens terrorem contra adversarios gestet in pectore. Cristam cum galea ponunt ut cerebrum sapientis et armatum sit et decorum. Unde et Plautus (Trinum. 851) in Trinummo ait, "Hic fungino certe est capite, totum se tegit." Triplici etiam veste subnixa est seu quod omnis sapientia sit multiplex sive etiam quod celata. Longam hastam etiam fert quod sapientia texta extrinsecus longe verbo percutiat; triplici etiam veste quod omnis sapientia texta intrinsecus rarius cognoscatur. In huius etiam tutela noctuam volunt quod sapientia etiam in tenebris proprium fulgorem possedet. Inde etiam et conditricem Athenarum volunt eam. Minerva denique et Athene Graece dicitur quasi ἀθάνατος id est immortalis virgo quia sapientia nec mori potest nec corrumpi. (Fulg. Myth. II. 2; cf. Albric. Phil. 8; Myth. Vat. I. 21, 124; II. 39, 119; III. 5, 4; III. 10, 6.)

III. 11. Gradivus dicitur quasi cratos divinus (κράτος θεοῦ), id est potens deus vel secundum etymologiam quod gradatim eundum sit in proelium. (Cf. Ser. Aen. I. 292; III. 35; Is. Or. VIII. 11, 52; Fest. 97; Myth. Vat. III. 11, 10.)

16. Id est non venit vulnerabilis nostris armis, habens membra dura quasi aes aut adamas. Adamans enim lapis est Indus parvus et indecorus , ferrugineum habens colorem crystalli; numquam ultra magnitudinem nucis avellanae repertur. Hoc nulli cedit materiae nec ferro quidem nec igni nec umquam incalescit; unde et nomen interpretatione Graece indomitam vim accepit. Sed dum sit invictus ferri ignisque contemptor, hircino rumpitur sanguine recenti et calido maceratur sicque multis ictibus ferri frangitur. Cuius fragmenta sculptores pro gemmis insigniendis perforandisque utuntur. Hoc autem dissidet cum magnate lapide in tantum ut iuxtapositum ferrum non patiatur abstrahi: magneti autem, si admotus magnes comprehenderit, rapiat auferatque. Fertur quoque in electri similitudinem venena deprehendere, metusque vanos expellere, maleficis resistere artibus. Genera eius sex. (Is. Or. XVI. 13, 2-3; Solin, 52, 53-57; Plin. N. H. XXXIV. 147; XXXVI. 126-127; XXXVII. 61; XX. 2; XXXVII. 55; Myth. Vat. III. 8, 10.)

27. Oenopion rex cum filios non haberet, a Iove Neptunoque quos hospitio susceperat hortantibus ut ab his aliquid postularet, petiit ut sibi concederent liberos. Illi intra corium immolati Iovis (l. bovis) sibi urina facta praeceperunt ut obrutum id est infossum terra completis mensibus solveret. Quo facto inventus est puer cui nomen ab urina impositum est ut Οὐρίων diceretur, quod Dorica ligua commutatum est ut diphthongus in ω longum converteretur. Quod autem prima syllaba brevis invenitur, ut hoc loco et apud Vergilium (Aen. I. 535) "Cum subito adsurgens fluctu nimbosus Orion" cum sit naturaliter longa, Graecae rationis est. Nam detractio est litterae et remanet brevis. Ceterum si sit in nomine proprio dichronos, ut omnes Latinae sunt, non abutemur propriorum nominum licentia. Orion ergo postea venator immensi corporis fuit, qui quodam tempore susceptus a rege Olyntho nomine cum eius filiam Meropen vitiarat, ille eius oculos sustulit. Caecus itaque Orion cum consuleret quemadmodum oculos posset recipere responsum est ei posse lumina restitui, si per pelagus ita contra orientem pergeret ut loca luminum radiis solis offerret; quod ille efficere potuit. Nam cum audisset strepitum Cyclopum Iovis fulmina fabricantium, sono ad eos ductus unum de his suis humeris (add. altera manus, Cedylionem nomine) superposuit et eo duce oraculi praecepta complevit. Hunc Hesiodus fabulose dicit a Neptuno accepisse donum ut super undas maris ambulasset. Post recepto vero lumine, in orientalibus partibus redisse nec se ulcisci in Olyntho rege in Cretam fugisse et cum Diana multas bestias peremisse. Sed cum vellet cum Diana concumbere ut Horatius dicit (Od. III. 4, 71-72) eius sagittis occisus est: ut Lucanus (IX. 836), inmisso scorpione perit et deorum miseratione relatus est in sidera, signum famosum tempestatibus fecit. Verisimilius autem est a scorpione interemptus quo oriente occidit. Orion ergo qui et Incola dicitur ante Tauri vestigia fulget; et ductus Orion ut supra diximus ab urina id est ab inundatione aquarum. Tempore enim hiemis abortus mare et terras aquis tempestatibus turbat. Hunc Latini Iugulum vocant quod sit armatus ut gladius et stellarum luce clarissimus atque terribilis. Qui si fulget serenitatem portendit, si obscuratur, tempestatem innuit imminere. (Serv. Aen. I. 535, X. 763; Is. Or. III. 71, 10; Hyg. Fab. 195; Astr. Poet. II. 34; Plin. N. H. XVIII. 278; Plac. Th. VII. 256, 843; Schol. Arat. 331; Myth. Vat. I. 32, 33, II. 129. III. 15, 8.)

92. (Add.) *Mussant* id est susurrant. Nam *mussat* polysemus sermo est; nam aliquando veretur ut Vergilius (Aen. XI. 345) in

supradicto exemplo; modo dubitat, ut (Aen. XII. 657) "Mussat rex ipse Latinus" Alias susurrat, ut hic et in Vergilio de apibus (G. IV. 188) "Mussant oras et l." Et proprie mussare est obmurmurare et muto esse vicinum. (Serv. Aen. XI. 345; cf. XII. 657; Donat. Ad. 207; Non. 427, 17 M.)

100. Translatio ab inculta terra in qua propter neglegentiam sentes nascuntur. Situs autem est lanugo terrae quaedam ex humore procreata et fit in locis sole carentibus. (Serv. Aen. IV. 462.)

105. Apollinem indici solem voluerunt. Apollo enim Graece perdens dicitur, quod fervore suo omnem sucum virentium decoquendo perdat herbarum. Hinc etiam divinationis deum voluerunt sive quod sol omnia obscura manifestat in lucem seu quod in suo processu et occasu eius orbita multimodos significationum monstrat effectus. Sol vero dicitur aut ex eo quod solus sit aut quod solite per dies surgat et occidat. Huic quoque quadrigam adscribunt illam ob causam quod aut quadripertitis temporum varietatibus anni circulum peragat aut quod quadrifluo climate diei metiatur spatium. Unde et ipsis equis condigna huis nomina posuerunt, id est Erythraeus Acteon Lampos et Philogeus. Erythraeus Graece rubens dicitur quod sol a limine rubicundus exsurgat; Acteon splendens dicitur quod tertiae horae vehemens insistens lucidior fulgeat; Lampos vero dum ad umbilicum diei centritum conscenderit circulum. Philogeus Graece terram amans dicitur quod horae nonae proclivior vergens occasibus pronus incumbat. In huius tutelam laurum adscribunt, unde etiam eum amasse Daphnen dicunt Penei fluminis filiam. Et unde laurus nasci posset nisi de fluminis aquis? Maxime amica Apollinis ob hanc rem vocitata est quia illi qui de somniorum interpretatione scripserunt ut Antiphon Filocrus et Artemon et Serapion Ascalonites promittant in libris suis quod laurum si dormientibus ad caput posueris vera somnia esse visuros. (Fulg. Myth. I. 11 & 13; Myth. Vat. I. 37, II. 18-23, III. 8, 1-5.)

106. (Add.) Ideo autem in illo nemore columbae finguntur dare responsa quod lingua Thessalica peliades et columbae vatinatrices dicuntur. De qua Vergilius (G. I. 149) "Et victum Dodona negaret;" a qua etiam Iovis Dodonaeus dicitur. (Serv. Buc. IX. 13; Myth. Vat. I. 96.)

125. *Stat* polysemus sermo est. Nam aliquando *horret* significat ut in hoc loco et in Vergilio (Aen. VI. 300) ut "Stant lumina flammae" et (VII. 233) "Stabat acuta silex." Modo *plenum* est, ut (XII. 407) "Iam pulvere telum stare videt;" et (Buc. VI. 53) "Stant et

iuniperi et castaneae hirsutae." Aliquando *positum* ut (III. 63) "Stant manibus arae." Item *placet* ut (XII. 678) "Stat conferre manum Aeneae;" et (II. 750) "Stat casus renovare omnes." Pro loco ergo hic sermo intelligendus. (Serv. Aen. I. 646; Non. 391 M.)

143. *Functum*, ab humanis periculis liberatum. Nam *functos officio* dicimus qui officia debita compleverunt; unde et *defunctos* mortuos dicimus qui compleverunt vitae officia. (Cf. Is. Diff. Verb. 124.)

186. Athamas post furorem a Iunone inmissum cum occiso Learcho Melicertam alterum filium cum uxore sua persequeretur, pervenerunt in quendam montem; de quo cum se in mare praecipitassent, voluntate numinum in deos versi sunt, Melicerta in Portunum qui Gracece Palaemon dicitur Ino in Matrem Matutam quae Graece dicitur Leucothea. (Serv. Aen. V. 241; Hyg. Fab. 1; Plac. Th. VII. 241, I. 12; Myth. Vat. II. 78, 79.)

202. Speculam bene dixit; quia quando speculationem significamus, feminini generis est ut (Verg. Aen. III. 239) "Specula Misenus ab alta." Speculum autem in quo intuemur generis neutri ut via vel speculum civis vel sarcina belli. (Cf. Varro L. L. VI. 82.)

203. Acteonem dicit. Curiositas enim semper periculorum germana detrimenta suis amatoribus novit parturire quam gaudia. Acteon denique, venator Dianam lavantem dicitur vidisse qui in cervum conversus a canibus suis non agnitus eorumque morsibus devoratus est. Anaximenes, qui de picturis disseruit libro II. ait venationem Acteonem dilexisse: qui cum ad maturam pervenisset aetatem, consideratis venationum periculis, id est, quasi nudam artis suae rationem videns timidus factus est et cor cervi habere fingitur; ebriose canis habens et cor cervi. Sed dum venandi periculum fugeret affectum tamen canum non dimisit quos inaniter pascendo paene omnem substantiam perdidit: ob hanc rem a canibus suis devoratus esse dicitur. (Fulg. Myth. III. 3; Myth. Vat. II. 81, III. 7, 3.)

273. Crimen erat adulterium quod cum Marte concubuit, quam Sol inveniens Vulcano prodidit. Ille adamante catenas effecit ambosque dis turpiter iacentes ostendit. Illa dolens, quinque filias Solis amore succendit id est Pasiphaen Circen Phaedram Medeam et Dircen. Quod sibi in hoc poeta garrulitatis illudit inquiramus. Praestant nunc in nostra vita de hac fabula certa admodum testimonia. Nam virtus correpta libidine Sole teste apparet. Unde Ovidius (Met. IV. 172) "Videt hic deus omnia primus." Quae quidem virtus cor-

repta libidine turpiter concatenata fervoris constrictione tenetur. Haec utique quinque Solis filias id est quinque humanos sensus luci ac veritati deditos quasi Solis fetus hac corruptela fuscat; ob hanc rem etiam huiuscemodi nomina quinque ipsis filiabus voluerunt. Primam Pasiphaen ut visum id est quasi *πασιφαήν* quod nos Latine omnibus apparentem indicimus. Visus enim reliquos quattuor sensus inspicit quia eum qui clamat videt et palpando notat et odorando intendit. Secundam Medeam quasi auditum hoc est *μηδέν ἰδέαν* quod nos Latine nudam visionem dicimus; vox enim corpore nuda est. Tertia Circe tactui similis id est quasi diceret *χειρῶν κρίνη*, quod nos manuum indicium dicimus. Quarta Phaedra quasi odoratus vel si dicat *φέρων ἡδύν* quasi offerens suavitatem. Quinta Dirce saporis index id est quasi *δριμὺ κρίνη* quod nos Latine acre iudicans dicimus. (Fulg. Myth. II. 10; Myth. Vat. II. 30, III. 11, 6.)

304. Sensus. Non possum facere quod rogas quia iussus sum implere praecepta fatorum et Iovis voluntatem. Sane et *hos monitus* dicimus ut (Pers. I. 79) "Hos pueris monitus patres infundere lippos," et *haec monita*, ut (Verg. Aen. VIII. 336) "Carmentis nymphae et deus auctor Apollo." (Serv. Aen. X. 689.)

311. *Quando* non est modo temporis sed significat *siquidem* et est coniunctio ratiocinantis. Sane *quando* brevis est naturaliter: sic Serenus "Quando flagella ligas Italica." (Septimii, ut videtur, novum fragmentum.) Sed Vergilius usurpavit (Aen. III. 500): "Si quando Tybrin vicinaque Tybridis arva." (Cf. Charis. 225, 21; Prisc. II. 88, 26; Prob. 145, 32 K.)

321. Aut etiam ideo *trisulca* dicit pro *quadrisulca* quia est fulmen quod terreat, est quod afflet ut (Vergilius Aen. II. 649) "Fulminis afflavit ventis;" est quod puniat ut (Verg. Aen. IV. 25), "Pater omnipotens adigat me fulmine ad umbras." Peremptorii autem fulminis late patet significatio. Est quod praesagit ut (Verg. Buc. I. 17) "De caelo tactas memini praedicere quercus." Aut revera ideo dixit *trisulca* quia tria sunt numina (l. nomina) fulminis; fulgur fulgor fulmen. Fulgur quod tangit, fulgor qui incendit et urit, fulmen quod findit: ideo et cum ternis radiis pingitur. (Cf. Serv. Aen. I. 43 D., II. 649, VIII. 524 D.; Sen. Q. N. II. 39; Varro L. L. V. 70.)

353. *Nec iussa incuso,* id est non redarguo vestra iussa; et bene dixit. Nam incusare proprie est superiorem arguere ut in Terentio (Heaut. 960) pater ad filium, "Quid me incusas, Clitipho? "Accusare

vero vel parem vel superiorem ut in eodem (Hec. 205) ad maritum uxor, "Me miseram, quae nunc quam ob causam accuser nescio." Et hoc proprietatis est licet usus male corrumpat. Sciendum tamen est Terentium quoque sola proprietate omnibus comicis esse praepositum quibus est quantum ad cetera spectat, inferior. (Serv. Aen. I. 410; Is. Diff. Verb. 303.)

Piget improprie dixit. Nam *piget* ad futurum spectat, *pudet* vero ad praeteritum. Et licet paene una sit significatio, tamen dicimus piget me illud facere, pudet fecisse: unde et praecipue interdum a Sallustio (Iug. 94, 5; Hist. Frag. I. 77, 13 M.) simul ponuntur. (Serv. Aen. IV. 336.)

Funere, cadavere; (pro eo) quod praecedit id quod sequitur. Funus enim est iam ardens cadaver quod dum portatur exequias dicimus; crematum, reliquias; conditum iam, sepulchrum. (Serv. Aen. II. 539; cf. Is. Or. XI. 2, 35.)

363. Heroas dicimus (a) Iunone traxisse nomen quae Graece Hera vocatur. Et ideo nescio quis eius secundum Graecorum fabulas heros fuit nuncupatus velud mystica significante fabula; quod aer Iunoni deputetur ubi volunt heroas habitare, quo nomine appellantur. Alicuius meriti animas defunctorum quasi heroas id est viros aereos et caelo dignos propter sapientiam et fortitudinem dicunt. (Is. Or. VIII. 11, 98, I. 39, 9; cf. Serv. Buc. IV. 35; Aug. Civ. Dei X. 21 d ed. Ben.)

407-8. Describit finem diei et noctis initium. Poetae enim dicunt solem in oceanum mergi indeque mane emergi (l. emergere). Quod ideo fingitur quia sol et ceterae planetae aquis oceani pascunt suos ignes.

413. (Add.) Quattuor equos fertur habere Phoebus; quorum nomina haec sunt, Zantheus, Zantus, Etheo et Dios. Vel quattuor tempora anni vel quattuor commutationes diei; unde et ipsis nominibus ostenditur quomodo sol muteter per diurnas horas. Nam Zantheus interpretatur rubeus et mane sol rubet. Zantus floridus; et tertia hora diei sol quasi floret dum inque (l. in quartam) profectus est. Etheus aereus et in meridie sol ferventior videtur et ideo quasi aereus. Dios clarus et nona hora descendente sole clarior liquet esse. Quorum nomina edidit Martialis libro VIII. (21, 7) dicendo "Quid cupidum Titana tenes am Xanthus et Ethus? Frena volunt." (Cf. Fulg. Myth. I. 11.)

432. Novem insulae quae sunt post fretum Siciliae appellantur Aeoliae, ab Aeolo rege filio Hippotae; licet habeant et propria no-

mina. Unde et Vergilius (Aen. VIII. 416) ait. "Aeoliam Liparen." Poetae quidem fingunt hunc regem esse ventorum unde modo iste dixit (Aen. III. 432) "Aeolio carcere." Sed ut Varro dicit, rex fuit insularum ex quarum nebulis et fumo Vulcaniae insulae praedicens futura flabra ventorum ab imperitis visus est ventos sua potestate retinere. (Serv. Aen. I. 52; Is. Or. XIV. 6, 36-37; Myth. Vat. II. 52, III. 4, 10, III. 10, 5.)

Carcere, custodia noxiorum. Carceres vero pluraliter ostia, quibus equi vel venti arcentur: unde et carcer quasi arcer ab arcendo. (Is. Or. V. 27; cf. Varro L. L. V. 151, 153; Diomed. 327; Dub. Nom. 575, 14 K.)

439. Fabulam tangit quae talis est: Post vitiatam Latonam Iuppiter cum etiam eius sororem Asterien vitiare vellet, illa optavit a dis ut in avem verteretur versaque est in coturnicem. Etiam (cum) vellet mare transfretare quod est coturnicum, afflata a Iove et in lapidem conversa diu sub fluctibus latuit. Postea supplicante Iovi Latona, Delos superferri aquis coepit; ipsa est enim quae nunc Delos dicitur. Haec primum Neptuno et Doridi fuit consecrata; postea cum Iuno, Pythone inmisso, gravidam persequeretur, terris omnibus expulsa, tandem aliquando adplicante se littoribus a sorore suscepta est. Et illic Dianam primo, post Apollinem peperit, qui statim occiso Pythone ultus est matris iniuriam. Sane nata Diana parturienti Apollinem matri dicitur obstetricis officium praebuisse. Unde cum Diana sit virgo, tamen a parturientibus invocatur; haec namque est Diana Iuno Proserpina. Nata igitur duo numina terram sibi natalem errare non passa sunt: eam duobus insulis religaverunt Mycono et Gyaro. Unde Vergilius (Aen. III. 73-5) "Sacra mari colitur medio gratissima tellus Nereidum matri et Neptune Aegaeo quamvis Arquitenens et littora circum errantem Mycono e celsa Gyaroque revinxit." Veritas vero longe alia est. Nam haec insula cum terrae motu laboraret qui fit sub terris latentibus ventis ut Lucanus (III. 460) "Quaerentem erumpere ventum," petito oraculo Apollinis terrae motu caruit. Nam praecepit ne illic mortuus sepeliretur et iussit quaedam sacrificia fieri. Postea e Mycono Gyaroque vicinis insulis populi venerunt qui eam insulam tenerent; quod Vergilius latenter ostendit dicens (Aen. III. 76) "Immotamque dedit coli et contempnere ventos." Quod autem diximus Dianam primam natam (esse), rationis est; nam constat primam noctem fuisse, cuius instrumentum est Luna id est Diana; post diem quem sol effecit, qui est Apollo. Ut autem Delos primo Ortygia diceretur factum est a coturnice quae

Graece ὄρτυξ vocatur. Delos autem quia diu latuit et post apparuit; nam δῆλον Graece manifestum dicitur, vel quod verius est cum Apollinis responsa ubique obscura sint manifesta illinc dantur oracula. Delos autem et civitas dicitur et insula; unde interdum recepit praepositionem. (Serv. Aen. III. 73; Myth. Vat. I. 37, II. 17, III. 8, 3; Plac. Th. IV. 795, V. 533; Ach. I. 206, 388; Is. Or. XIV. 6, 21.)

478. Serapis enim omnium maximus Aegyptiorum fuit deus. Ipse est Apis rex Argivorum qui navibus transvectus in Aegyptum, cum ibidem mortuus fuisset, Serapis appellatus est, propterea quia arca in qua mortuus ponitur quam sarcophagum vocant σορός dicitur Graece et ibi eum venerari sepultum coeperunt priusquam templum eius esset instructum velud σόρος. Apis Sorapis primo, deinde una littera commutata Seraphins dictus est. Apis vero fuit apud Aegyptios taurus Serapi consecratus et ab eo ita cognominatus quem Aegyptus instar numinis colebat eo quod de futuris daret quaedam manifesta signa. Apparebat enim in Memphis (sic) quem certum (l. centum) antistites prosequebantur, reperte (l. repente) velud lymphatici praecanebant. Huius capitis imaginem sibi in heremo Iudaei fecerunt. (Is. Or. VIII. 11, 85-6; Aug. Civ. Dei XVIII. 5 E. F.; Solin. XXXII, 17-21; Myth. Vat. I. 79; Comm. Lucan. VIII. 475.)

480. (Add.) Pan deus est rusticus in naturae similitudinem formatus; unde et Pan dictus est id est omne. Habet enim cornua in similitudinem radiorum solis et lunae: rubet eius facies ad aetheris imitationem. In pectore nebridem habet, id est pellem pictam vel loricam stellatam ad stellarum imaginem; pars eius inferior hispida est propter arbores virgulta. Caprinos pedes habet ut ostendat terrae soliditatem: fistulam septem calamorum habet propter harmoniam caeli in qua septem soni sunt ut Vergilius (Aen. VI. 646) "Septem discrimina vocum;" recurvum baculum, propter annum qui in se recurrit. Hic quia totius naturae deus est a poetis fingitur cum Amore deo luctatus et ab eo victus quia ut legimus (Vergilius Buc. X. 69) "omnia vincit amor." Ergo Pan secundum fabulas amasse dicitur Syringa nympham, quam cum persequeretur, illa implorato terrae auxilio in calamum conversa est. Quem Pan ad solatium amoris incidit et sibi fistulam fecit. (Serv. Buc. II. 31; Is. Or. VIII. 11, 81-3; cf. Myth. Vat. I. 127, II. 48; Comm. Luc. III. 442.)

506. (Add.) Hunc postea propter revocatum Hippolytum Iuppiter interemit. Unde Apollo iratus Cyclopas fabricatores fulminum confecit sagittis, ob quam rem a Iove iussus est Admeti regis VIIII

annis armenta pascere divinitate deposita. (Serv. Aen. VII. 761; Myth. Vat. I. 46, 118, II. 43, 128, III. 8, 17.)

In huius etiam tutelam corvum ponunt sive quod solus contra rerum naturam in mediis ipsis aestivis fervoribus ovipares pullulant fetus: unde et Petronius (XXVI. B.) "Sic contra rerum naturae munera notae corvus maturis frugibus ova refert." Sive quod in horoscopicis libris secudum Anaximandrum solus inter omnes aves laevas significationes habet vocum. (Fulg. Myth. I. 12; Myth. Vat. I. 115, II. 22; Comm. Arat. 427.)

Corvum autem postea Apollo pro remuneratione quia adulterium Coronidis ei prodidit ex nigro album fecit. (Serv. Aen. VII. 761.)

511-12. *Dampna c.* Bene addidit "Feralia dampna canens." Non tantum omnimodo malum est bubonis omen, sed cum canit pessima est, quippe cantus eius fletum imitatur et gemitum. Tacens vero ostendit felicitatem. Omnes enim aves oscines malae, praepetes vero bonae sunt. Quidam enim feminini generis dicunt esse bubonem, quidam vere masculini, ut Lucanus (V. 396) "Et laetae iurantur aves bubone sinistro. Item Ovidius (Met. VI. 432?) "Insandus (sic) bubo." Et hoc est invisu. Sed Vergilius feminino genere protulit referentem ad avem (Aen. IV. 462) "Ferali carmine bubo." Plerumque enim genus relicta specialitate ad generalitatem transit; ut si dicas bona turdus referendo ad avem; item si dicamus prima id est littera *a* cum sit neutri generis. (Serv. Aen. IV. 462; Serg. in Don. 494, 20 K.)

516. O pater Amphiarae equidem saepe tuli omina varia Phoebi; iam tum cum Thessala pinus duceret me virentem inter semideos reges. Hi duces obstipuere me canentem casus terrae marisque; nec saepius me locuto ventura Mopsus auditus est a Iasone in dubiis rebus. Sed non notavi ego ante similes metus aut astra prodigiosa.

577. *Agmina* multitudinem. Nam *agmen* polysemus sermo est; nam aliquando *impetum* significat, ut Vergilius (Aen. II. 212) "Illi agmine certo Laocoonta petunt." Aliquando *multitudinem* ut hic et in eodem (VI. 572) "Vocat agmina saeva sororum." Et etiam *incedentem exercitum* agmen vocamus. (Cf. Serv. Aen. I. 186, II. 212, 782, VI. 572, G. I. 322; Is. Or. IX. 3, 64.)

606. Fores proprie dicuntur quae foras aperiuntur sicut apud veteres fuit. Valvae autem sunt ut dicit Varro quae revolvuntur et se vellunt. Ianua autem est primus domus ingressus, dicta quod Iano consecratum est omne principium; cetera intra ianuam ostia

vocantur generaliter, sive valvae sint seu fores quamvis usus ista corruperit. (Serv. Aen. I. 449; cf. Is. Or. XV. 7, 4-6; Diff.Verb. 308.)

IV. 95. Lubricum dicitur et quod labitur dum tenetur ut piscis serpens et locus in quo labitur ut (Vergilius Aen. V. 335) "Et sese opposuit Salio per lubrica surgens." (Serv. Aen. II. 474; cf. Is. Or. X. 159, XII. 4, 2, XIV. 8, 36.)

120. Notandum est quia pubes quando ad multitudinem refertur ut hic tantum feminini generis est; quando vero ad singulos tunc est communis generis ut hic et haec pubes. Nam quod Sallustius dicit (Iug. 28) "Puberes omnes interfuerunt iube (l. interfici iubet)," venit ab eo quod est puber. (Serv. Aen. V. 546; cf. Charis. 548, 8; Prob. Cath. 19, 32 K.)

120. Pleiades Graeci a pluralitate nominaverunt, Latini vero ab eo quod vere exoriantur Vergilias finiunt. Dicuntur autem Pleiades ἀπὸ τοῦ nare (πλέειν), (Serv. G. I. 138; Is. Or. III. 71, 13; Hyg. Fab. 192; Poet. Astr. II. 21; Gell. XIII. 9.)

Sunt autem septem stellae, quarum septima ut ait Aratus (322) vix intueri potest, quam quidem fabulose gentiles pro timore Orionis fugisse putant. Quidam a sole persecutas arbitrantur vocatamque Electram quae non sustinens videre casus pronepotum fugerit; unde et illam dissolutis crinibus propter luctum ire asserunt et propter comas cometen appellari. Nonnulli vero Meropen esse autumant, quae nupta a quodam viro nominata sit Hippodamia. Est autem signum ante genua Tauri quod occasu suo hiemem, ortu aestatem primaeque navigationis tempus ostendit. (Cf. Serv. G. I. 138; Hyg. Fab. 192; Myth. Vat. I. 234.)

148. Alumnus est qui Graece τρόφιμος .dicitur, quod nomen quia Latinum non est, ut ab eo quod est nutritor inventamus eum qui nutritus est, transit ad nomen aliud et alumnum dixit. (Serv. Aen. XI. 33.)

Et dicitur alumnus et qui nutrit et qui nutritur. (Is. Or. X. 3.)

169. (Add.) Hydra serpens qui fuit in Lerna Argivorum palude. Sed Latine excetra dicitur quod uno caeso tria capita excrescebant. Sed constat hydram locum fuisse vomentem aquas vastantes vicinam civitatem in quo, uno meatu clauso, multi erumpebant quod Hercules videns loca ipsa exussit et sic aquae clausit meatus. Nam hydra ab aqua dicta est. Potuisse autem hoc fieri, ille indicat locus ubi Vergilius dicit (G. I. 87) "Excoquitur vitium atque exudat inutilis humor." (Serv. Aen. VI. 287; Myth. Vat. III. 13, 4.)

174. Chalybes populi sunt apud quos nascitur ferrum: unde

abusive dicitur Chalybs ipsa materies ut (Vergilius Aen. VIII. 46) "Vulnificusque Chalips." (Is. Or. XVI. 21, 1.)

Hos enim semper legimus esse nudos ut apud Vergilium (G. I. 58) "At Chalybes nudi ferrum." Aut quia apud illos arbores non sunt aut propter ferri caedendi studium; nam legimus (Aen. VIII. 425) "Brontesque Steropesque et nudus membra Pyragmon." (Serv. G. I. 58; cf. Aen. VIII. 446; Myth. Vat. III. 10, 5.)

259. Inter Caietam et Terracinam oppidum constitutum est a Laconibus qui comites Castoris et Pollucis fuerunt et ab Amyclis provinciae Laconicae civitate ei inditum nomen est. Lacones itaque isti cum secundum Pythagoream sectam a caede omnium animalium abstinerent—unde Iuvenalis (XV. 173-4) "A cunctis animalibus abstinuit qui tanquam homine"—et ex vicinis paludibus natas serpentes occidere nefas putarent, ab isdem interempti sunt. Unde Vergilius (Aen. X. 564) Amyclas dixit tacitas id est Pythagoreas. Nam Pythagorea virtus est quinquennale silentium. Et est alia expositio: cum frequenter falso nuntiarentur hostes et inani terrore civitas quassaretur, lata lege cautum est nequis umquam hostes nuntiarent, et postea cum vere hostis veniret, nullo nuntiante ex improviso civitas capta est. Vel Amyclae et tacitae dictae sunt: unde Lucilius (immo Afranius, Prodit.) "Mihi necesse est loqui, nam scio Amyclas tacendo perisse." (Serv. Aen. X. 564; Solin, 7, 8.)

266. Huc illucque vagabundum. Notandum vero quod *sinus* quando gremium significat *si* corripitur; quando vero significat vas in quo lac mulgetur, *si* producitur: ut Vergilius (Buc. VII. 33) "Sinum lactis et haec liba P. q. a." (Serv. Buc. VII. 33.)

325. Cornus si arborem significat, declinatur ut ficus. Nam cornu animale indeclinabile est, licet genetivum usurparit, ut Lucanus (VII. 217-8) "Cornus tibi cura sinistri Lentule." (Serv. Aen. III. 22.)

411. Tripos est species lauri tres habens radices Apollini consecratas, cui fertur esse divinatio. Tripos enim mensa Apollinis corio Pythonis operta in qua divinabant. (Cf. Serv. Aen. III. 92, 360, VI. 347; Plac. Th. I. 509; Myth. Vat. II. 20, III. 8, 5.)

492. Vellera vocat pilleum vel etiam lanam quae erat in summitate pillei. Nam flamines in capite habebant pilleum in quo erat brevis virga desuper habens lanae aliquid: quod cum per aestus ferre non possent, filo tantum capita ligare coeperunt. Nam nudis penitus eos capitibus incedere nefas fuerat: unde a filo quo utebantur *flamines* dicti sunt quasi *filamines*. Verum festis diebus filo deposito

pillea necesse erat recipere quae secundum alios ad ostendendam sacerdotii eminentiam sunt reperta, sicut columnae mortuis nobilibus superponuntur ad ostendendum eorum columen. Alii dicunt non propter eminentiam dignitatis hoc factum, sed quia cum sacrificarent apud Laurolavinium et eis exta frequenter aves de vicinis venientes lucis arriperent, eminentia virgarum eas terrere voluerunt, et exinde etiam consuetudo permansit ut apud Laurolavinium ingentes haberent virgas non breves ut in urbe. (Serv. Aen. VIII. 664; Varro L. L. V. 14; Is. Or. VII. 12, 18-9; Myth. Vat. III. 4.)

570. (Add.) Ex cuius sanguine lacus excrevit qui usque hodie appellatur Dirce: unde idem poeta in tertio (204-5) "Aut verso qui sanguine fluxit in subitos regina lacus. (Cf. Hyg. Fab. 7.)

655. (Add.) Sed post aliquantum tempus morbus inmissus est Atheniensibus talis ut eorum virgines furore quodam compellerentur ad laqueum: responditque oraculum sedari posse hanc pestilentiam si Erigonis et Icari cadavera requirerentur. Quae dum diu quaesita sunt, ad ostendendam suam devotionem Athenienses ut ea in alieno quaerere viderentur elemento, suspenderunt de arboribus funem ad quem se tenentes homines hac atque illac agitabantur ut quasi per aera quaerere viderentur illorum cadavera. Sed cum plerique caderent, inventum est ut formas ad oris sui similitudinem facerent et eas pro se suspensas moverent (l. cillerent) id est moverent ora. Nam cillere est movere: unde et *furcillae* dictae sunt scilicet quibus frumenta cilluntur. Unde Vergilius (G. II. 389) "Tibique oscilla ex alta s. m. p." (Serv. G. l. l. Aen. XII. 603; Schol. Bern. G. I. 33; Arat. 95; Hyg. Fab. 230; Fest. 194; Varro ap. Macr. Sat. I. 31, I. 11, 47-9; Is. Or. XI. 1, 6, XX. 14, 11; Myth. Vat. I. 19, II. 61.)

803. Hoc tractum est de historia Romana. Cum adhuc Romanus exercitus pauper esset sub Romulo, hastis foeni maniplos inligabant et hos pro signis gerebant; unde hoc nomen remansit, unde et milites manipli dicuntur. Et etiam signiferi manipli dicuntur qui secundum antiquum morem in legione erant triginta, legio autem habebat septem cohortes octoginta centurias. Est enim *ma* brevis; ars quidem exigebat ut *ma* haberet accentum, *ni* enim longa quidem est, sed ex muta et liquida. Quod quotiens fit, tertia a fine sortitur accentum ut latebrae tenebrae. Tamen in hoc sermone ut secunda a fine accentum habeat usus obtinuit. (Serv. Aen. XI. 870; Is. Or. IX. 3, 50, XVII. 9, 106, XVIII, 3, 5; Donat. Eun. 776; Victor Or. G. R. 22.)

829. *Hactenus saevisse,* id est sufficiat tibi quod hactenus

saevierunt tui alumni et quod pessima fuerunt acta populorum in te morantium. A modo sis plena quietis et tranquilla omnibus sicut nobis fuisti.

843. (*Velis*). Cupias nos libenter agnoscere praebendo nobis latices. Sane inter *agnosco* et *cognosco* superfluam quidam volunt facere discretionem ut cognoscamus novos, agnoscamus antiquos. Sed haec a poetis metri necessitate variantur. (Cf. Is. Diff. Verb. 62, 134.)

V. 50. Mons Aetna ex igne et sulphure dictus est unde et gehenna. Constat autem ab ea parte hunc qua Eurus vel Africus flat habere speluncas plenas sulphuris et usque ad mare deductas quae speluncae recipientes in se fluctus ventum credant (l. creant). Qui agitatus ignem gignit ex sulphure; unde est quod videtur incendium. (Is. Or. XIV. 8, 14.)

Hoc autem verum esse illa comprobat ratio quia et aliis flantibus ventis nihil ex se mittat, et pro modo flatuum Euri vel Africi interdum fumum, interdum favillas, nonnumquam vomit incendia.

Lemnos autem insula est in qua Vulcanus a Iove praecipitatus est et illic nutritus est a Sintiis; qui cum fulmina Iovi fabricasset non est admissus ad epulas deorum. (Serv. Buc. IV. 62; Myth. Vat. I. 128, 176; II. 37, 40.)

Postea a Iove promissum accepit ut quicquid vellet, praesumeret; ille Minervam in coniugium petiit, Iuppiter vero imperavit ut Minerva armis virginitatem deferenderet; dumque cubiculum introirent certando Vulcanus semen in pavimentum iecit unde natus est Erichthonius. Eris enim Graece certamen dicitur χθών vero terra nuncupatur; quem Minerva in cistam abscondit draconeque custode apposito duabus sororibus Aglauro et Pandorae commendavit (qui primus currum repperit). Vulcanum dici voluerunt quasi furiae ignem; unde et Vulcanus dicitur quasi voluntatis calor. Denique et Iovi fulgora facit vel furorem concutit. Ideo vero eum Minervae coniungi voluerunt quod furor etiam sapientibus subripiat (l. subrepat). Illa vero armis virginitatem defendit id est omnis sapientia integritatem morum suorum contra furiam virtute animi vindicat. Unde quidem Erichthonius nascitur. Ἔρις enim Graece dicitur certamen, χθών vero non solum terra quantum etiam dici potest unde et Thales Milesius ait ὦ χθών δόξης κοσμικῆς φθάρσις id est invidia mundanae gloriae consumptio. Et quidnam aliud subrepens furor sapientiae generare poterat nisi certamen invidiae? Quod quidem sapientia id est Minerva abscondit in testa id est in

corde servat (*supra*, vel celat) omnis sapiens furorem suum in corde celat. Ergo Minerva draconem custodem apponit (id est perniciem) quem quidem duabus virginibus id est Aglauro et Pandorae commendat. Pandora enim universale munus dicitur, Aglaurus vero quasi iustitiae oblivio. Sapiens enim dolorem suum aut benignitati commendat quae omnium munus est aut oblivioni sicut de Caesare dictum est "Qui oblivisci nihil amplius soles quam iniurias." (Serv. G. III. 113; Hyg. Fab. 166; Arat. 156; Fulg. Myth. II. 14; Is. Or. XVIII. 34, 2; Myth. Vat. I. 128; II. 37, 40; III. 10, 3.)

Lemnius autem Vulcanus ideo dicitur quia in Lemnum insulam ut diximus cecidit a Iunone propter deformitatem deiectus quam aerem constat esse ex quo fulmina procreantur. Ideo autem de femore Iunonis fingitur natus quia fulmina de imo aere nascuntur; quod etiam Lucanus dicit (II. 269-71) "Fulminibus vestrae propior succenditur aer pacem summa tenent." (Serv. Aen. VIII. 454; cf. 414; Myth. Vat. II. 40; III. 10, 4.)

Et quod crebro in Lemnum insulam iacitur fulmen, ideo in ea dicitur cecidisse Vulcanus. (Serv. Aen. VIII. 414.)

Claudus autem dicitur, quia per naturam numquam rectus est. (Serv. Aen. VII. 414; Aug. contra Faust. XX. 9, vol. VIII, 337 D.)

52. Athos mons est Macedoniae altior nubibus tantoque sublimis ut in Lemnum eius umbra pertendat quae ab eo septuaginta sex milibus separatur. (Plin. N. H. IV. 73; Solin. 11, 33; Is. Or. XIV. 8, 10.)

56. (Add.) Aegaeum dicitur a quodam saxo vel ut quidam volunt, insula quae visentibus procul caprae similis videtur quam Graece *αἶγα* vocant. (Plin. N. H. IV. 51; Fest. 24; Solin, 11, 2; Is. Or. XIII. 16.)

71. Mutus Hymen id est amor nuptiarum (l. nuptialis). Nam proprie hymen membranula uteri dicitur et est proprie muliebris sexus, in qua fiunt puerperia. Inde dictus est Hymenaeus deus. Praeter hanc sunt duae aliae viris et mulieribus communes, quarum una in cerebro est de qua fistula quinque pertiti sensus profluunt et Graece μηνιαῖα dicitur. Et est alia quae dividit inferiora ventris et superiora pectoris, quam Graeci φρήν dicunt. Unde et frenesis passio uueata (l. derivata) est et frenicus homo; quia siquis hanc laesam habuerit, in amentiam vertitur. (Serv. Buc. VIII. 30; Aen. I. 651; IV. 99; Donat. Ad. 907; Is. Or. IX. 7, 22.)

75. Thraces populi sunt qui nati sunt ex filio Iafet, qui vocatus Teras a quo et cognominati, licet gentiles eos ex moribus ita dictos

existimant quod sint truces. Saevissimi enim omnium gentium fuerunt: unde et multa de eis fabulosa narrantur (*supra,* vel memorantur), quod captivos dis suis litarent et humanum sanguinem in ossibus capitum portare (sic) soliti essent. De quibus Vergilius (Aen. III. 44) "Heu fuge crudeles terras, fuge littus avarum," quasi crudelium et avarorum. (Serv. Aen. III. 44; Is .Or. IX. 2, 82; cf. IX. 2, 31.)

Ideo iste *tumidos* dixit rebelles; hoc enim falsum est quod adversus eos velint pugnare, sed propter eorum filias ire volebant quasi in matrimonium detinerent; quia Lemniades eorum uxores ut supra diximus hircini foetoris plenae erant. Sed propter pudorem et turpitudinem tacuit mutans narrationem. (Cf. supra V. 29; Myth. Vat. I. 133, II. 141.)

120. (Add.) Recentiore utitur exemplo. Aut enim ad tempus respexit quod paulo ante fictum fuit quia proprie est Thracia in qua Progne fuit. Cuius fabula talis est: Tereus rex Thracum fuit qui cum Pandionis Athenarum regis filiam Prognen nomine duxisset uxorem, et post aliquantum tempus ab ea rogaretur ut sibi Philomelam sororem suam videndam accerseret, profectus Athenas, dum adducit puellam eam vitiavit et ei linguam ne facinus indicaret abscidit. Illa tamen rem in veste suo cruore descriptam misit sorori, qua cognita Progne Ityn filium interemit et patri epulandum apposuit, postea omnes in aves mutati sunt, Tereus in upupam, Itys in fassam, Progne in hirundinem, Philomela in lusciniam. (Serv. Buc. VI. 78; Myth. Vat. I. 4, II. 217.)

144. Scythia regio est Asiae cognominata a Magog filio Iafet sicut et Gothia; cuius terra ingens fuit, postea vero minor effecta est. Cui subiacet Hyrcania ab occasu habens pariter gentes multas propter terrarum infecunditatem vagantes. Ex quibus quaedam agros colunt, quaedam portentuosae ac truces carnibus humanis et eorum sanguine vivunt. Scythiae plures terrae sunt locupletes, inhabitabiles tamen plures. Nam dum in plerisque locis auro et gemmis fluunt gryphorum immanitate accessus hominum carus est. Quam expugnaverunt Amazones. (Solin. 15, 22; Is. Or. XIV. 3, 31-2.)

Amazones autem dictae sunt eo quod simul viverent sine viris quasi ἁμα ζῶσαι sive quod adustis dexterioribus mammis essent, ne sagittarum ictus inpediretur quasi ἄνευ μάζου. Nudabant enim quam adusserant mammam. Nam hoc est Amazon quasi ἄνευ μάζου id est sine mamma. Has iam non esse dicit quod partim earum ab

Hercule, partim ab Achille vel Alexandro usque ad internecionem deletae sunt. (Serv. Aen. I. 490; Iustin. II. 11; Plac. Ach. I. 353; Is. Or. IX. 2, 64.)

175. Delubrum dicitur quod uno tecto plura complectitur numina, ut Capitolium in quo est Minerva Iuppiter Iuno.

Alii dicunt delubrum esse locum ante templum ubi aqua currit a diluendo. Est autem synechdoche, a parte totum. (Serv. Aen. II. 225, IV. 56; Fest. 73; Ascon. 101, 12; Macr. Sat. III. 4, 1.)

Certe autem ligneum simulacrum delubrum dicimus a libro hoc est ligno facto quod Graece ξόανον dicitur. (Is. Or. XV. 4; Diff. Verb. 407.)

183. Cyclades antiquitus insulae fuerunt quas inde Cycladas autumant dictas quod licet spatiis longioribus a Delo proiectae sunt, tamen in orbe circa Delon sitae sunt. Nam orbem Graece κύκλος Grai locuntur. Quidam vero non quod in orbem digestae sunt, sed propter scopulos qui circa easdem sunt dictas putant Cycladas. (Solin. 11, 17; Is. Or. XIV. 6, 19.)

Haec in Hellesponto inter Aegaeum et Malaeum mare constitutae circumdantur. Sunt autem omnes numero quinquaginta tres, tenentes a septentrione in meridiem milia quinquaginta, ab oriente in occasum milia ducenta. Metropolis earum Rhodus. (Plin. N. H. IV. 65; Is. Or. XIV. 6, 20.)

336. Argo navem dicit quae in Pelio Thessaliae fabricata est. Cicero (i. e. Enn. Med. ap. Cic. Inv. I. 91; Auctor ad Her. II. 34) "Utinam ne in nemore Pelio caesae securibus ad terram cecidissent abiegenae trabes."

417. Castorem dicit fratrem Pollucis et Helenae. Nam iste bene dicitur Tyndaris quia filius fuit Tyndarei et Ledae et solus mortalis, Pollux vero et Helena abusive qui non Tyndarei, sed Iovis et Ledae filii fuerunt et immortales. Ut Vergilius (Aen. VI. 121) "Si fratrem Pollux alterna morte redemit," qui immortalitatem cum fratre partitus est. (Cf. Serv. Aen. II. 601, VI. 121.)

418. Malus arbor navis generis est masculini. Horatius (Od. I. 14, 5) "Nec malus est celeri saucius Africo." Et dictus est malus vel quia malos habet instar mali in summitate vel quia quibusdam malis ligneis cingitur, quorum volubilitate elevantur vela levius. (Serv. Aen. V. 487; cf. V. 829; Is. Or. XIX. 2, 8.)

427. *Palladios* radios quos Pallas invenit: ut in pacis petitione ramus olivae cum vittis afferebatur partim fabulae partim naturae efficit ratio. Nam cum de nomine Athenarum Neptunus et Minerva

contenderent et iussisset Iuppiter ut illius nomine diceretur civitas qui melius optulisset munus, equum Neptunus, Minerva olivam optulit quae res melior est comprobata, et pacis insigne et statim vincit. Unde cum eius ramus alicui offertur indicat eum esse meliorem; hinc est illud proverbium herbam do id est victori cedo, quod Varro in Aetiis ponit, cum in Agonibus herbam in modum palmae dat aliquis ei cum quo contendere non conatur et fatetur esse meliorem. Vittas autem habere ramus debet (quod iste praetermisit), ideo ut inertiam et imbecillitatem offerentis ostendat. Scimus enim oves egere semper aliena auxilio. (Serv. G. I. 12, Aen. VIII. 128; Hyg. Fab. 164; Myth. Vat. I. 2, 119, II. 119, III. 5, 4.)

432. Zethum et Calain filios Boreae et Orythyiae vel Ismarii et Aquilonis, alatos iuvenes quos Argonautae miserunt postea in adiutorium Phineo regi Arcadiae. Hic enim suis liberis superduxit novercam cuius instinctu eos necavit; ob quam rem irati di ei oculos sustulerunt et adhibuerunt Harpyas quae cum ei diu cibos abriperent, Iasonem cum Argonautis suscepit hospitio. Cui etiam ductorem dedit; hoc ergo beneficio ille et (l. illecti) Argonautae supradictos virentur pulsas de Arcadia pervenerunt ad insulas quae appellantur flotae et cum ulterius tendere vellent, ab Iride ammoniti sunt ut desisterent a Iovis canibus suos converterunt volatus quorum conversio id est στροφή nomen insulis dedit quod Apollonius plenius exequitur. (Haec ordinanda sunt secundum Serv. Aen. III. 270; cf. Hyg. Fab. 18; Plac. Th. VIII. 255; Myth. Vat. I. 27, II. 142, III. 5, 5ss.)

443. (Add.) Cur autem hoc evenit talis est ratio: Aegeus mortua Hippolyte, Phaedram Minois et Pasiphaes filiam superduxit uxorem Hippolyto. Qui cum illam de stupro interpellantem contempsisset, falso delatus ad patrem est qui ei vim voluisset deferre. Ille Aegaeum patrem rogavit ut se ulcisceretur; qui agitanti currum Hippolyto inmisit focam in littore, qua equi territi eum traxerunt. Tunc Diana eius castitate commota eum per Aesculapium in vitam filium Apollinis et Coronidis revocavit. Hunc Iuppiter propter revocatum Hippolytum interemit, unde Apollo iratus Cyclopas fabricatores fulminum confixit sagittis; ob quam rem, divinitate deposita, Admeti regis pavit armenta. Quapropter obsequiis eius emeritus ei favebat tamen, apud quem passus videbatur iniuriam. Sed Diana Hippolytum revocatum ab inferis in Aricia nymphae Egeriae commendavit et eum Virbium quasi bis virum iussit vocari. (Serv. Aen.

VII. 761, cf. VI. 445; Hyg. Fab. 47; Plac. Th. II. 506; Myth. Vat. I. 46, II. 128.)

505. Ideo autem *sacer* invenitur pro *execrabile* quia apud antiquos etiam de bonis execrandorum sacrae res fiebant: unde et supplicia passorum. Sallustius (Cat. IX. 2) "In suppliciis deorum magnifici." (Serv. Aen. I. 632, cf. III. 57; Fest. 318; Plac. Th. IV. 198; Is. Or. VI. 19, 82.)

Aut etiam sacer, *venerabilis*. Nam horror plerumque ad odium pertinet, plerumque ad venerationem ut Lucanus (V. 411) "Arboribus suus horror inest."

556. Demum id est postremum, novissime. Et haec particula tam apudVergilium quam apud omnes idoneos auctores hoc significat licet in aliis diversa significet. (Cf. Serv. G. I. 47; Corp. Gloss. VI. 322.)

579. (Add.) Distat enim inter consertum et consitum, quod consertum dicimus sermonem et consertas fabulas, consitum vero lignum et consitas arbores.

Hoc idem interest inter insitum et insertum. (Is. Diff. Verb. 320; cf. Serv. G. II. 32.)

597. Rapta est cutis, id est contracta. Et bene dixit cutem quae in corpore prima est. Et dicta est cutis quod ipsa corpori supposita incisionem prima patiatur; cutis enim (l. κοπή) Graece incisio dicitur. Idem est pellis quod externas iniurias corporis tegendo pellat pluviasque et ventos solisque ardores perferat. Pellis autem mox detracta corium dicitur. Corium autem per derivationem a carne appellatur quod eo tegatur, sed hoc in brutis animalibus proprium est. (Is. Or. XI. 78-9.)

620. Indifferenter ponit deos et divos, quamquam discretio sit ut deos perpetuos dicamus, divos ex hominibus factos quasi qui diem obierint: unde et divos etiam imperatores vocamus. Sed Varro et Azanzenus contra sentiunt dicentes divos perpetuos, deos ex hominibus factos qui propter sui consecrationem timentur ut sunt di manes; quod tangit in XII. (i. e. Vergilius XII. 139) dicens "Diva deam stagnis quae fluminibus cum (sic) sonoris praeest. (Serv. Aen. V. 45; cf. Is. Diff. Verb. 168.)

656. *Ubinam* ut *ubidem* multi dubitant ubi esse debeat accentus, quia ibi et ubi naturaliter breves sunt, sed secundum rationem finalitatis plerumque producuntur in versu. Nescientes et hanc rationem quia pronuntiationis causa contra usum Latinis syllabis ul-

timis quibus particulae adiunguntur, accentus tribuitur ut musaque, illene, huiusce. Sic ergo et *ubinam*.

683-5. Ordo est: Si tanta voluptas sanguinis est, imbuite arma domi atque haec templa Iovis dudum irrata (l. irrita) impius ignis ferat id est auferat.

685. *Quid enim haud licitum*. Subaudies, si ratus sum ius esse dominoque ducique in vilem famulum exercere vindictam, cum tanti luctus premerent mea pectora.

735. *Olim* ex longo tempore. Tria enim tempora signficat: praeteritum ut his et in Vergilio (Aen. XII. 210) "Olim arbos." Et praesens ut in eodem (Aen. V. 125) "Tumidisque tunditur olim fluctibus." Olim futurum: (Aen. IV. 627) "Olim quocunque dabunt se tempore vires." (Cf. Serv. Aen. IV. 627.)

VI. 54. *Teneraque cupressu*, nigra funesta. Nam inferis consecrata est, quia numquam revirescit. Moris autem fuerat Romani ramum cupressi ante domum funestam poni, ne quisquam per ignorantiam pollueretur ingressus. Hinc Horatius (Od. II. 14, 23) "Nec te praeter invisam cupressum ulla brevem dominum sequetur." (Serv. Aen. III. 64, cf. III. 600, IV. 507 D, VI. 216; Fest. 63; Plac. Th. IV. 460.)

Cupressus autem ideo adhibetur ad funera quod per eam funesta ostendatur domus: sicut laetam domum frondes indicant festae. Varro tamen dicit pyras ideo cupressu circumdari propter gravem ustrinae id est incensionis (additamenta scribae nostri) odorem, ne offendatur populi circumstantis corona. Quae tamdiu stabat respondens fletibus praeficae id est praecantatoris (haec quoque nostri scribae sunt) principis planctum quamdiu consumpto cadavere et collectis cineribus diceretur novissimum ilicet, quod ire licet significat. Unde est (Vergilius Aen. VI. 231) "Dixitque novissima verba." (Serv. Aen. VI. 216; Comm. Lucan. III. 42; Myth. Vat. III. 6, 28.)

254 (276). Io paelex Iunonis, concubina Iovis cum qua dum Iuno invenisset Iovem coeuntem petiit ut eius potestati daretur: quod cum Iuppiter annuisset, Iuno adhibuit ei Argum custodem, omni tempore oculatum. (Cf. Serv. G. III. 152, Aen. VII. 780; Hyg. Fab. 145; Plin. N. H. XVI. 239; Plac. Th. VII. 186; Myth. Vat. II. 89.)

521 (543). (Add.) Huius Leandri fabula talis est: Leander et Hero Abydenus et Sestias fuerunt invicem se amantes. Sed Leander ad Hero natatu ire consueverat per fretum Hellesponticum, quod Seston et Abydon interfluit. Cum autem iuvenis oppressum tem-

pestate cadaver ad puellam esset delatum, illa se praecipitavit e turre. (Serv. G. III. 258; Myth. Vat. I. 28, II. 218, III. 11, 19.)

548 (570). (Add.) Id est fibulam aufert a chlamyde qua tenebatur in humeris—et hoc dixit bene—qua infrenatur; hinc et Graece nomen. (Cf. Fest. 348-9; Is. Or. XIX. 31, 17 & 33, 4.)

549 (571). *Artus* sunt quibus colligantur membra, dicti ab artando quod colligati invicem nervis artentur id est stringantur: quorum deminutiva fuit articula. Nam artus dicimus maiora membra ut brachia, articulos minora. (Is. Or. XI. 1, 84; cf. Fest. 17.)

553 (575). *Palladios haustus incubuit,* assumpsit. Nam apud Vergilium (Aen. I. 89) aliam habet significationem ubi ait "Ponto nox incubuit atra," id est invadit, et tunc dativum trahit: et bene, nam incubare est per vim rem aliam tenere. (Serv. l. l.)

564 (576). Olea est unde derivatur oleum, oliva vero fructus unde derivatur olium. (Serv. G. II. 63; Is. Diff. Verb. 410.)

Invenitur oliva pro arbore, ut Vergilius (Buc. VIII. 16) "Incumbens tereti Damon sic coepit olivae." Sed quod ex albis olivis fuerit expressum, vocatur spanum, a Graecis ὀμφάκιον appellatur; quod autem ex fulvis et nondum maturis, vocatur viride. Quod vero ex nimium maturis commune dicitur. Ex his autem ad usum vitae primum est spanum, secundum viride, tertium commune. Graece enim ἔλαιος dicitur ex quo tractum est ut oliva dicatur: est autem arbor pacis insigne cuius fructus diversis nominibus appellatur. Sunt orchades a similitudine testiculorum vocatae quos Graeci ὄρχεις vocant. Radiolae pro eo quod longe fuit. (Vid. locum Isidorianum infra laudandum). Paphiae a Papho insula unde prius ablatae sunt. Lycinae, eo quod ultimum dent lumen nam λύχνος lumen est. Pausia quam corrupte vulgi pusiam vocant, dicta quod paveatur id est intendatur, unde et pavimentum. Syria est dicta eo quod de Syria est ablata sive quia nigra est. Crustumina eadem est et volumis, dicta ab eo quod volam compleat sua magnitudine. Quidam autem volemum Gallica lingua bonum et magnum intellegunt. Ideo autem ungebatur oleo ut citius laberetur e manibus sequentium. (Haec maximam partem excerpta sunt ex Serv. G. II. 63, 64, 86 unde Is. Or. XVII. 7, 62 ss.)

620 (642). *Suspiria p.* id est anhelum laborem victrici palma conlatus est. Palma enim apud antiquos victoribus dabatur; unde et palma dicta est quia manus victricis ornatus est vel quia oppansis est armis in modum palmae humanae. Est enim arbor insigne victoriae, proceroque ac decoro virgulto diuturnisque vestita frondibus

et folia sua sine ulla successione conservans. Hanc Graeci dicunt φοίνικα quia diu duret, ex nomine avis illius Arabiae quae multis annis vivere perhibetur. Quae dum in multis locis nascatur, non in omnibus fructus perficit maturitate, frequenter autem in Aegypto et Syria. Fructus autem eius dactylia a similitudine digitorum nuncupati sunt, quorum etiam nomina variantur. Nam aliii appellantur palmulae similes myrobalano, alii Thebaici qui et nucales, alii muniles quos Graeci καρυωτούς vocant. (Is. Or. XVII. 7, 1; cf. Ambr. Hex. III. 13, 53.)

643 (665). Improbus versipellis et fraudulenter incedens qui dono clipeum accepit.

Clipeus enim est maius scutum dictus clipeus ἀπὸ τοῦ κλέπτειν σώματα id est a furendo (furando) corpora. (Serv. Aen. VII. 686; Is Or. XVIII. 12, 1.)

Sive ut quidam dicunt clipeus dicitur quasi clipeum a verbo cluo id est defendo, quia eo contra adversa tela nos defendimus; σῶμα Graece corpus. (Plin. N. H. XXXV. 12; Is. Diff. Verb. 17; Charis. 21-2 K.)

669 (691). Ordo: atque illi subito venit fortuna cui dulce est fiduciam inmodicae virtutis auferre.

704 (729). (Nunc). Aut magnos aut odiosos.

Caestus autem per diphthongon pugilum arma significat; habet etiam pluralem numerum et est quartae formae. Nam cestus cesti singulari sine diphthongo balteum Veneris significat. (Serv. Aen. V. 69.)

(742.) *Palaestra*, luctatio Graece a verbo πάλλω id est luctor: hinc luctator palaestrites dicitur ἀπὸ τοῦ πάλλειν id est a motu urnae quia per fortem (l. sortem) luctabantur. (Serv. G. II. 531; Is. Or. XVIII. 24.)

719 (744). (Suadebat). Hoc verbum quod est suadet secundum naturam dissyllabum est, sed multi trissyllabum putant, quod etiam si inveniatur, solutio dicenda est quomodo dicimus aena ena. Hoc autem solum huiusmodi verbum in Latino invenitur.

869 (894). (Add.) Antaeum enim in modum libidinis ponitur: unde et Graece ἀντίον contrarium dicimus. Ideo et de terra natus, quia sola libido de carne concipitur: denique etiam tacta terra virilior exsurgebat; libido enim quanto carni consenserit, tanto surgit iniquior. Denique a virtute gloriae quasi ab Hercule superatur. Nam denegato sibi terrae tactu commoritur, altiusque elevatus materna non potuit mutuari suffragia, quo evidentem suae rei fabulam

demonstrasset. Omnem enim mentem dum virtus in altum sustulerit et carnalibus etiam denegaverit aspectibus, victrix statim exsurgit. Ideo etiam in certamine dicitur desudasse quia rara est pugna quae cum concupiscentia vitiisque congreditur, sicut Plato in moralibus ait: "Sapientes viri maiorem cum vitiis pugnam quam cum inimicis gerunt." Nam et Diomedes (sic) Cynicus, dum dolore lamnii (l. ramicum) contorqueretur, et vidisset ad amphiteatrum omnes concurrentes, dicebat "Qualis hominum stultitia! currunt spectare feras hoc est (l. homines) repugnantes et me praetereunt cum dolore certantem." (Fulg. Myth. II. 7; Myth. Vat. III. 13, 2.)

IX. 149. *Astu* id est malitia. Nam proprie astutos malitiosos vocamus: unde in Terentio (And. 183) postquam de domino dixit servus "Astute," ille iratus ait, "Carnufex quae loquitur?" Cicero (Verr. Act. I. 34) "Ita fit ut tua ista ratio existimetur astuta, meum consilium necessarium." (Serv. Aen. XI. 704; cf. Is. Or. X. 6.)

195. Consuetudo fuerat apud antiquos ut de venatione aut de aliquo monstro quod damnum inferebat mortalibus, pars in lucis pars in templis deorum poneretur et quaedam in tholis deorum suspendebantur (l. suspenderentur), ut pelles: quaedam vero affigebantur (l. affigerentur) ut dentes et cornua. Ut Vergilius (Aen. IX. 406) "Suspendive tholo aut sacra ad fastigia fixi;" et imitatur hoc loco Vergilium qui ubicumque lucum ponit, sequitur consecratio, ut (Aen. IX. 3-4) "Luco tum forte parentis Pilumni Turnus sacrata valle sedebat." Lucus autem dicitur per antifrasin, quod minime luceat, ut bellum quod minime sit bellum: non quod ibi lumina sint causa religionis ut quidam volunt. (Serv. Aen. I. 441, IX. 406; Is. Or. XVII. 6, 7, XIX. 19, 6.)

203. Dissimulaverat se nescire: et notandum est quia dissimulamus nota, simulamus ignota, ut Sallustius (Cat. 5) "Simulator ac dissimulator." (Is. Diff. Verb. 515.)

209. *Timido* pro timenti. Nam *timidus* est qui semper timet, *timens* vero qui ad tempus formidat ex causa, ut iste pro perdito sene. (Is. Diff. Verb. 554.)

361. (Add.) Istae aves nidos faciunt in mari media hieme quibus diebus tanta tranquillitas est ut penitus nihil possit in mari moveri. Inde etiam ipsi dies *alcyonia* nominantur: unde Vergilius (G. I. 399) "Non tepidum ad solem pennas in littore pandunt dilectae Thetidi alcyones." (Serv. G. I. 399; Is. Or. XII. 7, 25; Myth. Vat. I. 9, II. 175.)

839. Hic quartae declinationis dixit *colus,* e contrario Vergilius

(Aen. VIII. 409) secundae dicit: "Cui tolerare colo tenuique Minerva." Quem etiam ut Servius (ad locum) dicit sequi debemus. (Serv. Aen. l. 1; cf. Prob. Cath. 24, 6 K.)

(*Severi*). Ex illa causa quia patrem eius Diana sagittis occiderat. "Virginea domitus sagitta." (Horatius Od. III. 4, 71 et Acron-Porhyr. ad locum.)

X. 51. Bene precantur opem Iunonis, quia Iuno a iuvando dicitur. Ideo et regnis praeesse dicitur, quod haec vita divinitus (l. divitiis) tantum studeat. Ideo etiam cum sceptro pingitur quod divitiae regno sunt proximae. Velato enim capite Iunonem ponunt quod omnes divitiae semper praegnantes sunt et nunnunquam aboriantur: in huius quoque tutelam pavum ponunt quod omnis vita potentiae petax, aspectu sui semper quaerat ornatus. Sicut pavus stellatam caudam curvavit, concavans alteriusque faciem ornet posterioraque turpiter nudet, ita divitiarum gloriaeque adpetitus momentaliter ornat, postremo tamen nudat. Unde et Theophrastus in Memorialibus ait τὰ ἄλλα περίγνωθι id est reliqua considera: et Salomon. "In obitu hominis nudatio operis eius." Huic etiam Irim quasi arcum pacis adiungunt, sicut quod varios ornatus pingens a curvato curvamine momentaliter refugit, ita etiam fortuna quamvis ad praesens ornata est citius fugitiva. (Fulg. Myth. II. 3; cf. Cic. N. D. II. 66 & 68; Varro L. L. V. 67 & 69; Serv. G. IV. 340; Myth. Vat. III. 4, 5.)

130. Iris dicta est quasi ἔρις disturbatio: numquam enim ad conciliationem mittitur sicut Mercurius, sed ad disturbationem et est ministra non tantum dearum sed et deorum. Et Vergilius haec probat dicens (Aen. IX. 800) "Aeriam caelo nam Iuppiter Irim demisit germanae haud mollia iussa ferentem." (Serv. Aen. IX. 2; Plac. Ach. I. 220; Myth. Vat. II. 6, III. 4, 2 & 6.)

257. (Add.) Dicendo portas aenas historiam tangit quae talis est: Brenno duce Senones Galli venerunt ad urbem et circa Alliam flumen occurrentem sibi deleverunt exercitum omnem populi Romani. Aliaque die cum vellent ingredi civitatem, primo cunctati sunt timentes portas et nullum in muris videbant. Postea paulatim ingressi vastaverunt cuncta octo integris mensibus, adeo ut ea quae incendere non poterant, manu militari diruerint, solo remanente Capitolio. Ad quod cum utensilibus reliqui fugerant cives qui tamen a Gallis obsidebantur, etiam ad id penetrare cupientibus, quos alii per dumeta et saxa aspera, alii per cunilos dicunt conatos ascendere. Tunc Manlius cunctos Capitolii Gallos detrusit ex arce clangore

anseris excitatos, quem privatus quidam Iunoni dono dederat. Namque secundum Plinium (Immo. Lucret. IV. 683-4) nullum animal ita odorem hominis sentit. Postea Romani in Capitolio fecerunt aeneas portas, ut nullus intrare vel exire valuisset nisi magno cum sonitu. Nam isti in tam brevi spatio minime portas aeneas fecerant. (Serv. Aen. VI. 825; Plin. N. H. X. 51, XXIX. 57; Myth. Vat. I. 221.)

303. Pro cavae testitudine. Est etiam perifrasis citharae cuius usus repertus est hoc modo: cum egrediens Nilus in suos meatus varia in terris reliquisset animalia, relicta etiam testudo est, quae cum putrefacta esset et nervi eius remansissent extenti intra corium inventa est a Mercurio eiusque digitis percussa sonitum dedit ex cuius imitatione cithara est composita. Ut Vergilius (G. IV. 463-4) "Ipsa cava solans aegrum testitudine amorem." (Serv. ad. l. 1; Is. Or. III. 22, 8; Myth. Vat. II. 43.)

373. (Add) Iovem enim pro aere posuit, aetherem vero pro nubibus. Chasma autem dicit id est subitam disruptionem et quendam recessum, aethera vero ut diximus pro aere posuit propter metrum quia in aethere hoc contingit, dum ventorum impetus nubiumque globositas illuc non attingat, sed summa serenitas, tranquillitas. Unde Lucanus (II. 273) "Pacem summa tenent." Nubes autem in medio aere sunt ubi fiunt omnia signa quae dicit; id est Iris, serenitas, chasma. Nam si in summo, nullus videre potuisset. Humani enim oculi altiorem et nimium splendorem ferre non possunt. Sane chasma est (ita etiam Plinius vocat) disruptio et quidam caeli discessus. (Serv. Aen. IX. 20; Plin. N. H. II. 96.)

503. Quamvis in omnibus libidinis amor sit turpior, numquam tamen deterior erit quam cum se honorato miscuerit. Libido enim honestatis noverca dum quid expediat nescit, est maiestati contraria. Qualis enim divinitas quaesit quod esse velit, ne quod fuerat esset. Iuppiter enim conversus in cygnm cum Leda concubuit quae peperit ovum; inde nati sunt tres Castor et Pollux et Helena. Sed haec fabula mystici saporem cerebri concipit. Iuppiter enim in modum potentiae ponitur, Leda vero dicta est quasi λοιδή quod nos aut iniuriam aut convicium dicimus. Ergo omnis potentia iniuriae mixta speciem suae generositatis mutat: ideo ergo in cygnum dicitur conversus, quod ferunt physioligi quam maxime Melissus Euboicus qui omnium physiologorum sententias disputavit, huius generis avem ita conviciis esse plenam ut ipsa clamante reliquae aves taceant quae praesto fuerint. Unde et olor dictus quasi ab ὀλιγωρία

tractum quod nos Latine iniuriam dicimus. Ergo quotiens cumque nobilitas in iniuriam vertit, conviciis misceatur necesse est. Sed quid ex haec re concipiatur videamus. Nihilomonus ovum quia sicut in ovo omnes sordities quae purgari potest in genere continetur intrinsecus, ita etiam in effectu iniuriae omnis est iniustitia, inmunditia; sed ex ovo generantur tres Pollux Castor et Helena. Nihilominus seminarium scandali et discordiae sicut ante diximus et geminum luctum concussit adultera mundo. (Fulg. Myth. II. 16; Myth. Vat. III. 3, 6-7.)

Castorem vero et Pollucem quasi in modum perditionis ponunt; unde et in mari Castorum signa dixerunt, quae periculum creant. Nam ob hanc rem etiam ambos alternatim resurgere atque occidere dicunt quod superbia nonnumquam vivat, nonnumquam occidat. Unde et ὑπερηφανία Graece dicitur superbia. Superefania proprie superapparitio nuncupatur, quod sicut in istis duobus signis quae eorum fratrum vocabulo nuncupaverunt, unus superappareat, alter vergat sicut lucifer et antifer. Nam Graece Pollux ἀπὸ τοῦ ἀπόλλειν est a perdendo et Castor quasi κακὸν ὕστερον id est malum extremum. (Fulg. Myth. II. 16.)

850. (Add.) *Vidit Aloidas*. Aloeus Ifigeniam (sic) uxorem habuit quae compressa a Neptuno duos peperit Otum et Ephialten, qui digitis novem per singulos menses crescebant; freti itaque altitudine caelum voluere subvertere. Sed sunt confixi Dianae et Apollinis telis. Aloidas autem sic dixit sicut de Hercule Amphitryoniden dicimus. (Serv. Aen. VI. 582; Myth. Vat. I. 83, II. 55.)

Cum crescerent. Propter Titanas dicit hoc. Terra enim contra Saturnum Titanas genuit, Gigantas vero postea contra Iovem: et ferunt fabulae Titanas ab irata Terra contra deos esse procreatos in eius ultionem. Unde et Titanes dicti sunt ἀπὸ τῆς τίσεως vel ab ultione. De his autem solus sol abstinuisse narratur ab iniuria numinum, unde et caelum meruit. (Serv. Aen. VI. 580; Albric. Ph. 12; Is. Or. IX. 2, 35; Myth. Vat. I. 11, III. 3, 5.)

XI. 92. *Fatiscunt*, laxantur vel aperiuntur vel abundanter solvuntur. *Fatim* enim abundanter dicimus, unde et *affatim*; *hiscere* autem aperire. (Cf. Fest. 11; Serv. Aen. I. 123; Corp. Gloss. V. 199, 11.)

187. *Iamque vale*. Varro in libris logistoricis (p. 258 R.) dicit ideo mortuis falsisque imaginibus *salve* dici et *vale* non quod aut salvere aut valere aut salvi esse possint, sed quod ab his recedimus eos nunquam visuri; hinc ortum est ut etiam maledicti significatio-

nem interdum *vale* optineat. Ut Terentius (Andr. 697) "Valeant qui inter nos discordiam volunt," hoc est ita a nobis discedant ut numquam ad nostrum revertantur aspectum. Ergo cum dicitur mortuo *vale,* non etymologia consideranda est, sed consuetudo, quod nullis *vale* dicimus nisi a quibus recedimus. (Serv. Aen. XI. 97; Donat. in Ter. l. l.)

394. *Longo post tempore* aut archaismus est, antiqui enim *post ante circum* etiam ablativo iungebant, quod hodie minime possumus facere: aut *longopost* una pars est orationis, ut sit sensus congredere nunc primum frater tempore *longopost*, sicut *multominus*, *postmodo.* Horatius (Sat. II. 627) "Quod mihi obsit clare multoque locuto." (Serv. Buc. I. 29; Serv. in Donat. 420, 11 K.)

XII. 434. (Add.) Orcus dicitur deus inferorum: ὁρκῶ Graece vero iuro, unde orcus dicitur; quasi enim iurat et affirmat se nullam animarum sine supplicio examineque dimissurum. Ipse enim dicitur Pluto. πλοῦτος Graece vel dives dicitur filius Saturni et Rheae, Terrae; nihil enim ditius inferno qui omnia recipit, licet et saturari nequeat. (Cf. Cic. N. D. II. 66; Serv. G. I. 277; Fulg. Myth. I. 4; Myth. Vat. III. 6, 1.)

497. (Add.) Hoc *asylum*, hoc est templum Misericordiae collocarunt unde nullus posset abduci, quod postea Romulus fecit: unde Vergilius (Aen. VIII. 342) "Hinc lucum ingentem quem Romulus acer asylum," hoc est ad imitationem Atheniensis asyli fecit. Quod ideo Romulus fecit, ut haberet advenas plures cum quibus conderet Romam. (Iuvenal. VIII. 272) "Et tamen ut longe repetas longeque revolvas, nomen ab infami gentem deducis asylo." (Serv. Aen. VIII. 342, cf. II. 761; Myth. Vat. I. 60, II. 166.)

ERRATA.

Page	9,	line	28,	for	uno read uno (l. verno)		
"	9,	"	30,	"	viderit. read viderit,		
"	9,	"	30,	"	Eaque read eaque		
"	9,	"	37,	"	suctransennas, read suci transennas		
"	12,	"	33,	"	magnate read magnete.		
"	14,	"	2,	"	Latinus"	"	Latinus".
"	15,	"	28,	"	canis	"	canis (oculos)
"	16,	"	8,	"	μεδέν	"	μηδὲν
"	17,	"	25,	"	occanum	"	oceanum
"	17,	"	37,	"	am	"	an
"	18,	"	28,	"	Neptune	"	Neptuno
"	19,	"	33,	"	amor	"	Amor
"	20,	"	19,	"	invisu	"	invisus
"	22,	"	19,	"	tiarent	"	tiaret
"	23,	"	20-21,	"	cader–ent	"	cade–rent
"	26,	"	37,	"	ἁμα	"	ἅμα
"	27,	"	14,	"	κύκλος	"	κύκλον
"	28,	"	10,	"	aliena	"	alieno
"	31,	"	37,	"	conlatus	"	consolatus
"	32,	"	27,	"	παλλειν	"	πάλλειν
"	35,	"	37,	"	physioligi	"	physiologi
"	37,	"	16,	"	Sst.	"	Epp.

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Observations on the Efferent Neurones in the Electric Lobes of Torpedo Occidentalis —

SHINKISHI HATAI

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OBSERVATIONS ON THE EFFERENT NEURONES IN THE ELECTRIC LOBES OF TORPEDO OCCIDENTALIS.

BY SHINKISHI HATAI,
(From the Biological Laboratory of the University of Cincinnati.)

CONTENTS.

I. MATERIALS USED AND TECHNIQUE EMPLOYED IN THE PRESENT INVESTIGATION.

For the present investigation, the efferent neurones in the electric lobes of *Torpedo occidentalis*, and the spinal ganglion cells from the mid-cervical ganglia of the adult white rat were used. The body weight of the rat was 141 grams. The torpedo material, which was generously furnished by Dr. Ayers, had been preserved with 10% formaline. To prepare this, a thin piece was cut from the lobe and transferred to distilled water for about six hours in order to remove all the formaline. After thorough washing with water, the material was transferred to 35% alcohol, where it remained about one hour, and then it was carried through graded alcohols and imbedded in paraffine in the usual way. The sections were cut 12 μ in thickness. For staining, a saturated aqueous solution of toluidin blue, and for contrast staining, an alcohol solution of erythrosin, were used.

The spinal ganglion of the white rat was preserved with the author's own mixture (formaline-acetic sublimate mixture) (*), and for staining, the reagents just mentioned were used.

II. Finer structure of the efferent neurones of the electric lobes in Torpedo occidentalis.

The efferent neurones of the electric lobes of *Torpedo occidentalis* are so large, more than 0.1 mm. in diameter, that they can easily be seen with the naked eye. Under moderate magnification, the cell bodies show numerous dendritic processes and the single axone is also visible in most cases.

The general form of the cell body is somewhat similar to that of the motor cells in the ventral horn of the spinal cord in man and the higher mammals. In most cases, the nucleus lies on the side of the cell-body towards the axis-cylinder process. The nucleus is nearly spherical, and very large in size proportionately to the cell-body (40–30 μ). The arrangement of the chromosomes in the nucleus is somewhat peculiar. They do not show minute spherules suspended in the delicate meshwork of the linin substance, but instead of that, irregular large masses which fill up meshes of the linin.

The nucleolus is always visible and lies at one pole of the nucleus. Curiously enough, the nucleolus, as a rule, lies in the same relative position in all the cells of a given section.

Under the higher magnification, the internal structure of the cell-body shows a fibrillar arrangement of the cytoplasm. The nature of this fibrillar structure will be discussed later on. In this chapter, only the general arrangements of these fibrils will be described.

Briefly speaking, the cell-body, except the nucleus presents everywhere a fibrillar arrangement of the cytoplasm. The following descriptions apply to the serial sections of one cell (102 μ in diameter, and 60 μ in thickness), and give a general idea of the structure above mentioned.

(*) Hatai, S.— Finer structure of the spinal ganglion cells in the white rat.—Jour. of Comp. Neurology, Vol. XI, No. 1, 1901.

Fig. 1 is a section passing through the periphery of the cell-body. In this figure, the dendritic processes are shown, but not the neuraxone. The position where the neuraxone will arise in the sections is marked by *A*. The fibrillar bundles which come from all dendritic processes of one side of the cell-body (*a*) take a curving course toward the axone hillock, thus forming an arrangement like an inverted U. Other fibrillar bundles come also from the dendrites on the other side (*b*) and take the same course toward the neuraxone. The dotted areas are interpreted as the cross-sections of the similar fibrillar bundles which, running through the cell-body in different directions, are therefore cut at different angles. In this figure, the fibrillar bundles connecting the dendrites with each other are shown very poorly.

Fig. 2 is the section nearer the center of the cell-body and follows Fig. 1. In this figure, the four dendrites are shown clearly, and the localities of the neuraxone is indicated by "*A*," although it does not appear at this level. The fibrillar bundles which form the neuraxone come from each of the dendrites. The dendrites themselves have close relations with each other by means of the connecting fibrillar bundles passing between them. The nucleus is surrounded by the fibrils coming from one of the dendrites (*c*). The fibrillar bundles which come from the dendrites (*d*) also take a part in investing the nucleus. The cross-sections of the fibrillar bundles show as clearly separated groups.

Fig. 3 is a section passing through the middle of the nucleus and follows Fig. 2. In this figure, the nucleolus is visible. The fibrillar arrangements are slightly different from those in the figures already given. In this section the fibrils do not form large bundles, but are divided into smaller strands and interwoven. The intimate connections between the dendrites are clearly shown. The nucleus is also surrounded by the bundles of the fibrils, which come from some of the dendrites. As a rule, in this level the fibrillar bundles near the nucleus are short, because bundles are, for the most part, cut more or less at right angles to their long axis. This suggests that the fibrillar bundles converge towards the nucleus. The peculiar arrangement of the fibrils near the

nucleus has been described as "vortex" or "spiral," or sometimes "Gitterähnliche Anordnung." On the contrary, the fibrillar bundles at the periphery present comparatively long sections. In this section, the neuraxone is not yet shown.

Fig. 4 is a section of the cell-body at another level. In this figure, three dendrites, nucleus, and neuraxone are clearly shown. The neuraxone "*A*" lies at one corner of the base of the rectangular cell-body. An intimate connection of each dendrite with that of the other, and also of all the dendrites with neuraxone is clearly shown in this figure. A curious arrangement of the fibrils is noticeable very near the axone hillock, where the fibrillar bundles have a beautiful spiral arrangement. This spiral arrangement is produced by the fibrils coming from various dendrites as is shown in the illustration. In this figure, connecting fibrils between the dendrites (*a*) and (*c*) are shown very clearly.

Fig. 5 is a section passing through the periphery of the side opposite to that shown in Fig. 1. In this figure, four dendritic processes are plainly shown — one from each corner of a somewhat rectangular-shaped cell-body. The position from where the neuraxone will arise in other section is marked by "*A*." A clear oblong space near the center of the cell-body is the place where the nucleus lies in the other sections. The fibrillar bundles which come from the dendrite (*a*) run towards the dendrites (*c*, *d*) along the one side of the nucleus, and finally enter the dendrites (*c*, *d*). Along the course, a few small fibrillar bundles diverge towards the periphery of the cell-body. The fibrillar bundles which come from the dendrites (*b*) run toward the dendrites (*c*, *d*) in a somewhat similar manner to those from the dendrite (*a*). In this case, the fibrillar bundles divide into two branches at the nucleus and after encircling the nucleus, they enter in the dendrites (*c*, *d*) and become continuous with those from the dendrite (*a*). From the base of the dendrite (*b*), small fibrillar bundles are distributed toward the neuraxone. From the dendrites *c*, *d*, the bundles of fibrils arise, and run toward the neuraxone. Along their course, these bundles are increased by the addition of numerous bundles of fibrils which come

from the periphery of the cell-body to form the yet larger bundles found in the axone hillock. The dendrites *a* and *b* are subdivided into two branches. In this case the branches are also connected by a few fibrils. These branches which are divided from the main dendrites (*a*, *b*,) receive fibrils from various regions of the cell-body.

From the above description, two important relations are evident: (1) That each dendrite is connected by the fibrillar bundles with several and possibly all the others, and (2) in each case, the nucleus is partially surrounded or encircled by the fibrillar bundles, on their way from the dendrites to enter into the neuraxone.

As a rule, the fibrils in the dendrites are very conspicuous, presenting long continuous lines, while in the cell-body they take tortuous or irregular courses, so that the cross-section of the cell-body presents minutely dotted areas, representing the cross-section of the bundles. From this, it is inferred that the entire course of some of the bundles must be very complex.

Fig. 6 is a diagram reconstructed from the serial sections of the cell-body in order to depict schematically its structure and to show the fibrillar tracts distributed throughout it. Let us take any one of the dendrites from the Fig. 6, and trace the lines which represent the fibrillar bundles. In the dendrite (*b*), black continuous lines present the out-going fibrillar bundles, while dotted lines in the same dendrite represent the in-coming fibrillar bundles from other dendrites. If we trace one of the black lines (3), it enters into the dendrites which lie in both sides, and other black lines (1) run toward the nucleus and partially encircle it. The fibrils continue from the nucleus toward the axone and finally enter into the axis cylinder. In the remaining dendrites, the fibrillar tracts are just the same in their distribution with those of dendrites (*b*).

In some cases, the fibrillar bundles which run from the dendrite not only enter into the dendrites which lie nearest on both sides, but they also connect with other dendrites further distant (2). In the cross-section of the cell-body, we notice very often the following appearance: The neighbor-

hood of the nucleus is composed of peculiarly arranged fibrils, forming a "spiral" or "swirl." These appearances are caused by the fibrils, which take very irregular courses and partially encircle the nucleus in a tortuous manner.

III. Finer structure of the ground substance of the spinal ganglion cells in the adult white rat.

It remains to discuss the real nature of the fibrillar structures mentioned above, and to this end the structure of the ground substance of the nerve-cells must first be considered.

Concerning the structure of the ground substance in nerve-cells, two main views are held: the "fibrillar" and "non-fibrillar" structure. The former theory may also be subdivided. One view is represented by the theory of Bethe (*) who regards the ground substance as composed of "Peri Fibrillär Substanz" and "Fibrillen." The so-called Fibrillen are independent individuals distributed throughout the cell-body in a certain way, where they neither anastomose nor branch. Another fibrillar theory is that of Apàthy ([1]). According to this author, the primitive neurofibrils are to be distinguished by means of special technique, in the nerve-cells as Bethe describes. These fibrils however, are not isolated, but are connected with each other by means of delicate branches, thus forming a very complicated anastomosis within the nerve-cells.

The non-fibrillar theories may also be divided into two groups, represented by the theory of Apàthy ([1]), Nansen ([2]), Bütschli ([3]), etc. Nansen holds the view of primitive tubular structure of the formation of the ground substance of the nerve-cells, that is, the ground substance is entirely composed of extremely small tubules which are directly continuous with the neuraxone.

(*) Bethe, A.—Über die Primitiv Fibrillen in den Ganglien-zellen von Menschen und Wirbelthieren.—Arch. für Mikrosk. Anat., Bd. 51.

(1) Apàthy.—Das leitende Element des Nervensystems, u. s. w.—Mitheil. d. Zoolog. Station zu Neapel, B'd XII, '97.

(2) Nansen, F.—The structure and combination of the histological elements of the central nervous system.—Bergen, '87.

(3) Bütschli.—Investigations on microscopic forms and on protoplasm.—'94. Translation to English.

Bütschli, Held [1], Van Gehuchten [2], Von Lenhossek [3], Ramon y Cajal [4], Marinisco [5], Ewing [6], a. o., hold the view of reticular or spongy formation of the ground substance, stating that the fibrillar structure described by others are not true fibrils but rows of fine granules which form the reticular arrangement of the ground substance.

The writer's observations on this subject are as follows: The ground substance of the spinal ganglion cells of the white rat exhibits a reticular structure as shown in Fig. 7. The meshes of the reticulum are very small but conspicuous. The size and form of the meshes vary. Generally, in the clear zone at the periphery of the cell-body, the meshes are always larger and more conspicuous than in the remaining part. In the neighborhood of the axone hillock the meshes are not only much diminished in size, but also they are much elongated along one axis. Around the nucleus, the meshes reach a minimum size. The form of the reticulum at the periphery shows meshes of a somewhat polygonal shape, but in the remaining part of the cell these meshes are elongated, especially around the nucleus and near the neuraxone. Upon examining with a higher magnification, the protoplasmic threads or filaments which forms the reticulum, we see that it is not smooth but has a somewhat varicose appearance, due to the presence of small bead-like arrangements on the course of the filaments. This bead was called by Held (*) a "neurosome," who discovered the occurrence of the neurosome not only at the connecting point of the net but also inside the net. The writer noticed the occurrence of these structures not only at the connecting points of the net but also in the course of the filament, but could not find them inside the reticulum.

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(1) Held.—Beiträge zur Strukturen der Nerven-zellen und ihren Fortsätze.—Erste Abhandlung. Arch. für Anat. und Entwickelungs. Anat. Abth., '95.

(2) Van Gehuchten.—Anatomie du systèm nerveux de l'homme.—Lauvain, 1894.

(3) Von Lenhossek.—Feinere Bau des Nervensystems.—'95. P. 147.

(4) Cajal.—Estructura del protoplasma nerviso.—Revista trimestral micrografica, Vol. I, fasc. 1, '96.

(5) Marinisco.—Pathologie générale de la cellule nerveuse.—La Presse Médicale, '97.

(6) Ewing.—Studies on ganglion cells.—Arch. of Neurol. and Psychopathol., Vol. I, No. 3. '98.

(*) Held.—Loc. cit.

This bead or neurosome has peculiar chemical affinities for the staining fluids. Eosin or erythrosin stain this element very deeply, so that it can easily be distinguished from the rest of structures. The fine filament joining these beads seems to be slightly different from the neurosome itself, as is shown by a slightly different staining reaction. It seems, indeed, that these neurosomes are a highly differentiated portion of the protoplasm which forms the reticulum.

The form and size of the neurosomes are different in different localities, as has been already described by Held. These structures are especially numerous within the axone hillock and intracellular extension of the axone. At the periphery of the spinal ganglion cells, the individual meshes of the reticulum are so large that the neurosomes are less crowded, hence, in this region, they are scattered very irregularly. But on the contrary, in the remaining parts of the cell, the meshes of the reticulum are elongated in shape and the rows of neurosomes become more crowded together, thus giving the fibrillar appearence. At first glance, this arrangement of neurosomes looks very much like the fibrils which have been described by many authors. Careful observations, however, show that these lines appearing like fibrils are composed of a row of minute beads arranged serially. Moreover, these pseudo-fibrils are connected by protoplasmic threads, thus forming the reticulum. This structure is shown in Fig. 7. Around the nucleus these neurosomes form somewhat concentric lines in a very beautiful manner. But gradually the figure becomes irregular as the reticulum approaches the periphery. This is the appearance generally found in the spinal ganglion cells. Sometimes the cell shows different arrangement of neurosomes, namely, concentric lines at the periphery but not in the neighborhood of nucleus. Still other variations in arrangement are found.

Graf (*) noticed the fibrils which are composed of a row of minute beads, in the Purkinji cells of human cerebellar cortex. He said: "The cytoplasma show the most beautiful fibrillar structure that I have ever seen. The fibrillæ are

(*) Graf, A.—On the use and properties of a new fixing fluid (chrom-oxalic.)—Bull. of Pathol. Institute of the New York Hospitals, '97. Vol. II, p. 386.

exceedingly fine and are very regularly arranged in the cell-processes and on the surface of the cell, whereas they form a more intricate network in the center of the cell, especially around the nucleus. By closer observation of a favorable spot (the best places are where the stain is not very intensive) we notice that the finest cytoplasmic fibrillæ are not smooth, like smooth muscle fibrils, for instance, but are composed of a row of minute beads closely arranged in single file."

Held believes that the fibrils, according to some investigators, are in reality identical with rows of neurosomes. He hints that some of the fibrils represent bands of neurosomes; other fibrils described by Flemming are bundles of cytospongium.

My own observations support Held's suggestion. My preparations show sometimes exactly the fibrillar structure described by Graf, and I find this condition in the efferent neurones of the Torpedo, as well as in the spinal ganglion cells in the white rat. These fibrils can always be resolved into rows of neurosomes.

Another important point is, that the meshes of the reticulum in the cell-body become more and more elongated toward the axis cylinder. Thus it looks as if the fibrils are radiating from the axone around the nucleus.

The peculiar character of the region from where the axis cylinder originates was first described by Schäffer ([1]).

This region of the cell-body he called the "axone hillock." It is admitted by most investigators that the axone hillock, as well as the axis cylinder, show a parallel arrangement of cytoplasm. The writer notices also these arrangements of fine cytoplasmic threads, which carry the neurosomes, showing a convergent arrangement toward the axis cylinder. In this region the meshes of the reticulum are very small, but careful examination shows that the axone hillock, as well as axis cylinder, are composed of an altered reticulum.

The arrangement of neurosomes, except in the axone hillock, is not the same in all nerve-cells, but differs according to the type of the cells.

(1) Schäffer, K.—Kurze Anmerkung über die Morphologische Differenz des Axen Cylinders in Verhältnisse zu dem Protoplasmatischen Fortsätze bei Nissl's Färbung.—Neurol. Centralbl., Leipzig, Bd. XII, '93, S. 849–851.

In the motor ganglion cells in the anterior horn of the spinal cord, the neurosome presents quite a different arrangement from that of spinal ganglion cells. In the former group the meshes of the reticulum do not show the honey-comb form, but an elongated shape. The cytoplasmic thread carries a great number of neurosomes, which form straight chains. These chains run parallel to the periphery toward the dendrites, as well as toward the axis cylinder. Around the nucleus, however, these chains have the arrangement found in the spinal ganglion cells.

The Purkinjii cells in cerebellar cortex in the white rat show still a different arrangement of neurosomes. In these cells the neurosomes accumulate at the base of the main dendrites, showing very intricate arrangement. But near the entrance of the dendrites the irregular chains rearrange themselves, forming a regular line of neurosomic fibrils. The remaining part of the cell-body show nearly the same arrangement as that of the spinal ganglion cells.

IV.—Remarks concerning the structure of the ground substance in nerve cells.

As has been mentioned already, the ground substance of the spinal ganglion cells of the white rat presents very clearly the reticular structure. This structure, however, is altered by the growth of cell-body; for example, the prolongation of the axis cylinder from the cell-body is accompanied by an elongation of the primitively polygonal meshes of the reticulum, thus giving a fibrillar appearance to the ground substance.

The same holds true in the case of the Torpedo. The apparent fibrils result from alterations in the reticulum, and, therefore, should not be compared to those of Bethe's. Although, in the case of the Torpedo, the reticulum is hard to see, yet it is sometimes clearly demonstrable in thin sections properly stained.

In the spinal ganglion cells of the higher mammalia, except in Dogiel's second type of cells, the cell - body sends off only one prolongation, while in the case of Torpedo, the efferent

neurones of the electric organ give numerous processes from the cell-body. In the former case, the meshes of the reticulum are changed gradually from a regular polygonal form to those much drawn-out in the axone hillock. In the case of the Torpedo, however, the arrangement of the reticulum is modified not only toward the axis cylinder, but in every part of the cell-body from which dendritic processes arise. The appearances in Torpedo can be explained as a result of the growth changes of the cell-body. Judging from what we find in the rat, we assume in the first place the spinal ganglion cell to be a spherical mass filled by the wide meshed reticulum. For the same reason we assume that this spherical mass is pulled out at each point where there is a dendrite, and thus modified as it is where the neuraxone is formed from the axone hillock. As a result, the primitive polygonal meshes are transformed mechanically by the growth changes and thus give rise to the fibrillar appearance. If numerous processes are formed by the cell, as in the case of Torpedo, then the resulting appearance is quite complex. But the principle of its formation is the same as in the more simple spinal ganglion cell. The so-called fibrillar arrangement in the writer's preparation is thus explained:

V.—Summary.

1. The efferent neurones of the electric lobes of *Torpedo occidentalis* present a fibrillar appearance of the ground substance.

2. This appearance, however, is due to an alteration in the shape of the meshes of the reticulum, and, therefore, it cannot be compared with the fibrils described by Bethe, Apàthy, and others.

3. The meshes of the reticulum, which are regarded as the primitive by the present writer, are altered by the growth of the cell-body where the processes, both axone and dendrite, arise and become extremely elongated in these branches.

4. Gradations from the primitive shape of the meshes to the altered form which appears fibrillar, are clearly visible in the spinal ganglion cells of the white rat.

VI.—Illustrations. (Plate I.)

Fig. 1–5—Five serial sections from a single efferent neurone in electric lobe of *Torpedo occidentalis*. Mean diameter of the cell-body (120 μ x 83 μ); of the nuclei (37 μ x 34 μ).

Fig. 6—Diagram showing the fibrillar arrangement of the efferent neurone in an electric lobe of *Torpedo occidentalis*.

Fig. 7—Spinal ganglion cell from the mid-cervical ganglia of the adult white rat. Cell-body (41 μ x 30 μ); nucleus (15 μ x 15 μ).

University of Cincinnati

BULLETIN NO. 4. OCTOBER, 1901. PLATE 1.

Fig. 1.

Fig. 2.

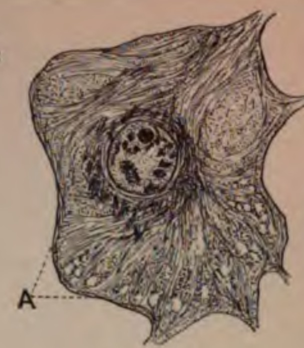

Fig. 3.

Fig. 4.

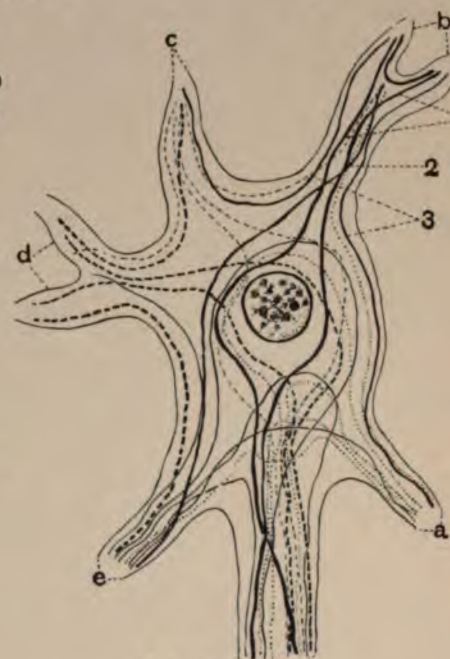

Fig. 6.

Fig. 5.

Fig. 7.

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An Investigation of the Vascular System of Bdellostoma dombeyi —

C. M. JACKSON

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AN INVESTIGATION OF THE VASCULAR SYSTEM OF BDELLOSTOMA DOMBEYI.

The *Cyclostomata* derive their interest and importance from the fact that they are not only the lowest of the *Craniata*, but also possess many structural features which are undoubtedly ancestral in their character. As Dr. Ayers has maintained, too little attention has been paid to this class, especially to the Myxinoid division. With the exception of Johannes Müller's "Vergleichende Anatomie der Myxinoiden" (published 1834–1842), the Myxinoids, especially Bdellostoma, have scarcely been touched. A closer examination of the anatomy of the blood-vascular system of Bdellostoma, and a discussion of a few points concerning its comparative anatomy in the light of our present knowledge, is the purpose of this paper.

The material used in the following investigation included several injected specimens, and a large number of uninjected specimens of *Bdellostoma dombeyi* collected by me during the summer of 1897, in the Bay of Monterey, at Pacific Grove, California. Carmine-gelatine was used for injection, and the specimens were preserved in alcohol-formalin mixture (95 per cent alcohol, 6 parts; 2 per cent formalin, 4 parts). For comparison I have used specimens of *Bdellostoma forsteri* (from the Cape of Good Hope), *Petromyzon*, *Myxine*, etc., belonging to Dr. Ayers, under whose direction the following investigation was made.

THE HEART.

(Figures I, II, III, also, IX, X, XIV).

The heart is composed of three chambers — sinus venosus, auricle, and ventricle.

The *sinus venosus* (Figs. I, II, S), (gemeinschaftlichen Körpervenenstamm of Müller), is that part of the heart which

receives the blood from the venous system. It is an elongated thin-walled sac, about 2 cm. in length, situated a little to the left of the median line, just above the anterior lobe of the liver, and between the sheets of mesentery which form the hepatic ligament. The larger posterior portion lies just below the alimentary canal, and anterior to the gall cyst. The smaller anterior portion lies beneath the auricle (A). The sinus lies outside the pericardial cavity, but is partially enclosed between the layers of the mesocardium. It is dilated posteriorly, being somewhat quadrilateral in outline, and compressed laterally. In this region the sinus receives, on the right side, the anterior and posterior hepatic veins (ha, hp). At the posterior extremity it receives the posterior common cardinal trunk (pcc). Anteriorly, it receives, on the left side, the left anterior cardinal vein (acl). The narrow anterior portion of the sinus venosus receives the inferior jugular vein (jv) just anterior to the sinu-auricular aperture, which lies in the dorsal wall near the anterior end.

The *auricle* (Figs. I, II, III, A) lies immediately above and anterior to the sinus. It occupies the left portion of the pericardial cavity, and is surrounded by the pericardium (its relations to which will be described in detail later). The auricle is the largest of the cardiac divisions, and, when expanded, almost completely fills the left pericardial cavity. When contracted, however, it is smaller than the ventricle, since it is very thin-walled. It is an elongated sac, irregular in shape, and flattened dorso-ventrally. The exact position and extent varies considerably in different specimens. It is somewhat irregularly convex, except the inner and upper walls. These are usually concave, on account of being closely apposed to the ventricle during life. The auricle usually lies for the most part on the left side of the alimentary canal. Posteriorly, the auricle is closely connected ventrally with the sinus, communicating with it through the sinu-auricular aperture. On the right side it communicates with the ventricle through a short canal, the *ductus auricularis*. (See Figs. I and II.) This duct, though well marked in some specimens, is obscured in others by the approximation of the auricular and ventricular walls. It is really a constricted portion of the auricle at the auriculo-ventricular aperture. The margin of the auricle

behind this duct usually projects as a lateral pocket into the right pericardial cavity. The auricle is attached ventrally and internally (*i. e.*, to the left) by the mesocardium. The anterior and posterior extremities of the auricle, however, project freely into the over-lying pericardial cavity.

The cavity of the auricle (Fig. III) is very irregular. Beside the three pocket-like spaces (anterior, posterior, and lateral), the cavity is made irregular by a network of muscular trabeculæ which project from the walls, and sometimes across the cavity. The auricle has two openings. The afferent, or sinu-auricular aperture, is in the posterior portion of the floor. On viewing the floor from above, the long narrow slit-like opening is seen extending diagonally from side to side. The opening is guarded by two thin membranous valves (Fig. III, sav), whose free margins readily allow the influx of blood, but effectually prohibit its reflux. A short distance anterior from the sinu-auricular opening we find the auriculo-ventricular aperture, an oval foramen, on the right side in the duct previously described. This aperture is also guarded by a pair of valves, semi-lunar in shape, one lying anterior and the other posterior to the opening. These valves are smaller but stronger than the sinu-auricular valves. During the flow of blood from the auricle into the ventricle they lie flattened against the sides of the duct, with their free margins extending toward the ventricle and offering no resistance to the flow of blood. During the ventricular systole the valves prevent the reflux of blood by the apposition of their free margins in the median line, completely closing the channel.

The *ventricle* (Figs. I, II, III, V) is an ovoidal sac, slightly elongated and flattened dorso-ventrally. The lateral margin on the left side, next to the auricle, is less convex than that on the right. The ventricle is nearly in the median line of the body, just below the alimentary canal. It lies to the right of the auricle, somewhat ventral and anterior to it. The wall of the ventricle is much thicker than that of the auricle, and encloses a cavity shaped like a Scottish bag-pipe (See Fig. III). The inner surface of the wall, like that of the auricle, is marked by projecting muscular trabeculæ. There are two openings into the ventricular cavity. The afferent,

or auriculo-ventricular is an oval foramen situated near the posterior end on the inner side. It corresponds to the end of the short ductus auricularis already described. The foramen ordinarily measures about a millimeter in diameter in individuals of fifty centimeters length. The afferent or aortic aperture lies at the anterior extremity of the ventricle. It is nearly circular in outline and is likewise guarded by a pair of strong semi-lunar valves, one dorsal and one ventral. These are the strongest and thickest of the cardiac valves. They contain much elastic tissue, and are continuous with the walls of the aorta at its base. Their action is similar to that of other valves.

Pericardial Cavity.

The alimentary canal in Bdellostoma is suspended from the mid-dorsal line of the body wall by a mesentery, which is formed by the reflection of the lateral peritoneal sheets. (See Fig. IV., m.). Ventral to the alimentary canal, in the anterior abdominal region, the liver is likewise enclosed by a continuation of the same mesentery. (See Fig. V, L). Above the anterior lobe of the liver, the lateral peritoneal sheets do not meet above the alimentary canal to form a distinct mesentery. They are widely separated, and in the space between them the pericardial cavity is formed, just above the anterior lobe of the liver. The relations of the peritoneal and pericardial cavities are shown in diagram VI, which represents a cross-section through that region. For convenience of description, we may conceive of the pericardial sac as formed by an evagination of the peritoneal membrane on the right side into the space above the anterior lobe of the liver, and below the alimentary canal. The sac formed by this evagination is in turn *invaginated* by the pushing in of the heart (V) from below. In this way the pericardial membrane becomes arranged to form a double wall made up of two layers — an outer (O), or parietal layer, which encloses the pericardial cavity (pcc), and which is reflected to form the inner, or visceral layer (i), which immediately invests the heart. By the approximation of the pericardial layers, where they are reflected over the heart, a ventral cardiac ligament, the *mesocardium* (cm) is formed. The mesocardium partially separates the general pericardial cavity into two unequal divi-

sions, right and left. These two cavities communicate freely with each other dorsally (above and behind the heart), but are entirely separated ventrally. The right pericardial cavity, which is the larger, remains in free communication with the peritoneal cavity through the *pericardio-peritoneal foramen* (pcf). The heart has therefore exactly the same relation to the pericardium and the pericardial cavity as the intestine has to the peritoneum and the peritoneal cavity. There is only this difference, that the mesentery is *dorsal* to the intestine, while the mesocardium is *ventral* to the heart.

The right pericardial cavity may be described approximately as an elongated lenticular cavity, 2–3 cm. long, flattened dorso-ventrally, and lying just above the anterior portion of the anterior lobe of the liver. The anterior end of the cavity is larger and extends somewhat toward the right. It includes that portion of the cavity which contains the ventricle. The posterior end of the cavity is narrower, and extends backward and toward the left. The right pericardial cavity, as a whole, is bounded above by the dorsal body wall; below by the anterior lobe of the liver; internally by the mesocardium and the intestine (which it partially surrounds); and externally by the reflected peritoneum, which lies for the most part against the dorso-lateral body wall. An imperfect septum, the *portal septum*, complete only in the posterior region, is formed by the reflection of the roof into the right pericardial cavity. It extends parallel to the long axis of the cavity, and partially divides it into two chambers — a smaller *outer* and a larger *inner* chamber. This double-layered portal septum in the middle portion surrounds the portal heart; anteriorly, the anterior portal vein runs between its walls; and posteriorly it surrounds the common portal vein.

The *outer chamber* of the right pericardial cavity lies external to the portal septum. It is a narrow cavity, about 2–3 cm. in length, lying parallel to the inner chamber. It communicates with the inner chamber below the septum throughout almost its entire length. Only the extreme posterior portion of the outer chamber, into which the lateral wall of the alimentary canal projects, is completely separated by the septum from the inner chamber. In the posterior region the outer chamber communicates laterally and externally with

the general peritoneal cavity, through a narrow slit about 1–2 cm. in length — the pericardio-peritoneal foramen. (See Figs. VI, X, XIX, pcf). The direction of the slit is not quite longitudinal, but extends slightly outward anteriorly. The lower margin of the foramen is formed anteriorly by the fold extending upward from the liver (hepatic ligament) (See Fig. VI). Posteriorly, the slit borders on the lateral wall of the alimentary canal. The upper margin of the slit is formed posteriorly by the body wall and anteriorly by a reflection of the peritoneum from the wall. Through the pericardio-peritoneal foramen passes the supra-intestinal vein closely attached to the lateral wall of the intestine. The anterior extremity of the *right mesonephros* extends through the foramen, projecting from the inner side of the roof. The floor of the outer chamber is formed anteriorly by the upper surface of the anterior lobe of the liver; posteriorly, by the fold extending from the upper surface of the lobe to the lower margin of the pericardial foramen. The roof of the outer chamber is in direct contact with the body wall. External to the portal heart, toward the anterior end of the chamber, the *right pronephros* projects downward and outward into the cavity, pushing the pericardium before it. Just behind the pronephros, and above (outside) the pericardium, along the inner margin of the chamber, lies the anterior end of the mesonephros, which extends backward through the pericardial foramen, as described. In the posterior region the outer chamber lies against the right side of the intestinal wall. Along this wall a fold of the pericardium extends from the pericardial foramen to the posterior end of the portal heart. This fold encloses the *supra-intestinal* vein. (See Fig. XIII.)

The *inner chamber* of the right pericardial cavity lies internal to the portal septum, and encloses the ventricle of the heart. It is much larger than the outer chamber, being of about the same length, but wider and deeper. The inner chamber is situated slightly ventral to the outer. Anteriorly, the chamber is about ¾ cm. deep. Posteriorly, it becomes shallower and narrower, terminating just anterior to the gall bladder, and above the anterior lobe of the liver. On the left side the inner chamber forms a blind sac into which a

lobe of the auricle projects. The roof of the inner chamber is in contact with the ventral surface of the alimentary canal. The floor lies upon the dorsal surface of the anterior lobe of the liver. The anterior wall lies against the connective tissue surrounding the last gill pouch on the right side. The external wall is formed by the portal septum, which is incomplete ventrally, leaving an extensive communication with the outer chamber. The inner wall is formed by the mesocardium, which is also incomplete. Above the mesocardium is a narrow longitudinal slit (about 1 cm. in length) through which the right and left pericardial cavities communicate. The ventricle of the heart occupies the anterior portion of the inner chamber. The double-layered mesocardium passes upward and outward from its attachment, soon dividing into two sheets which form the inner pericardial layer immediately surrounding the ventricle. (Fig. VI.) Anteriorly the inner pericardial layer becomes continuous with the outer, forming no pericardium. In this way the anterior end of the ventricle is *not covered* by the pericardium, but lies *outside* the pericardial space. The mesocardium is attached ventrally to the left margin of the anterior lobe of the liver. Posteriorly it encloses the sinus and veins opening into it.

The left pericardial cavity lies on the left side of the mesocardium, somewhat dorsal to the right cavity. It is a small elongated sac, which closely surrounds the auricle. The roof is in contact with the alimentary canal internally and the dorsal body wall externally. The floor and external walls touch the latero-ventral body wall. The inner wall is formed by the incomplete mesocardium, leaving the right and left pericardial cavities in communication dorsally. The exterior wall abuts against the postero-dorsal wall of the oesophago-cutaneous duct. Posteriorly, the cavity ends as a short blind pocket. From the roof the left pronephros and the left anterior cardinal vein project into the cavity, pushing the pericardium before them. The mesocardium extends into the left pericardial cavity and surrounds the ventricle on the right side. The postero-internal angle of the auricle often extends through the slit-like foramen above the mesocardium, and lies in a pocket within the right pericardial cavity. This relation is not constant, however.

Arterial System.

The *ventral aorta* (Figs. X, XVIII, Av.) consists of a principal median trunk, which divides anteriorly into a pair of lateral branches. The main trunk lies in the median line, just above the ventral body wall and below the pharynx. The length is about 3 cm. The lateral branches are a little longer. It extends from the anterior end of the ventricle to the posterior extremity of the "club-muscle." It lies between the last six or seven pairs of gills, and is imbedded in the peculiar brownish fatty connective tissue characteristic of that region. The median trunk of the aorta is nearly cylindrical in shape, but narrows slightly in caliber anteriorly. Posteriorly, at its junction with the ventricle, it is suddenly constricted. The relatively small opening from the ventricle is guarded by a pair of strong semi-lunar valves, as previously described. The short expanded portion of the aorta just beyond the constriction and behind the first gill branches represents the *bulbus aortæ*. This portion of the aorta is in contact ventrally with the dorsal surface of the anterior lobe of the liver.

The ventral aorta divides anteriorly into two branches (right and left) which pass forward, upward, and outward, along the dorso-lateral aspect of the posterior end of the club-muscle. The posterior end of the club-muscle, with reference to the point of branching, is variable, on account of the mobility of the former. The usual position is shown in Fig. X. But the muscle may be drawn forward, or even back below the point of division.

The *afferent branchial arteries* (Figs. X, XVIII, af. br.) rise on either side from the ventral aorta and its right and left branches. There are usually six or seven pairs arising from the median trunk, and from three to six pairs from the branches. Sometimes there is one more on one side than on the other, corresponding to the asymmetrical occurrence of the gills. The six or seven pairs from the median trunk are never symmetrically disposed. The last afferent branchial artery on the right side is always posterior to the corresponding left vessel. (See Fig. X.) The two pairs lying next anterior to the last are situated nearly opposite to each other,

while the remaining vessels from the median trunk are asymmetrical, the *left* vessels arising anterior to the corresponding vessels on the right side. The afferent branchial arteries arising from the right and left branches of the aorta are also asymmetrically placed, corresponding to the asymmetry of the gills. The afferent vessels vary in length, the anterior vessels being longer than those in the posterior region. Those from the main trunk are about 1–1.5 cm., while those from the lateral branches are 1.5–3 cm., increasing from behind forwards. The most anterior vessel is always the longest. In size they are all about equal. The direction of the arteries is external and slightly upward in the arteries from the main trunk, and forward, upward, and outward in those from the lateral branches. Each afferent branchial artery terminates on the postero-external wall of the corresponding gill pouch, just below the external gill passage.

The last afferent branchial artery of each side gives off a small branch a short distance from the gill. This branch possesses a lumen only at its origin, if at all. It soon becomes reduced to a slender string of connective tissue which becomes lost in the connective tissue around the "club-muscle." Attached to this string is a small spheroidal body, apparently made up of fibrous and fatty tissue. (See Fig. X, XIV.)

It may be remarked that in *Bdellostoma forsteri* this string may be traced from the branchial artery around to the dorsal aorta. The significance of these structures will be discussed later.

Branchial Circulation.

(Figs. VIII, IX, X, XIII.)

The gills of the Bdellostoma are lens-shaped pouches, compressed laterally, so as to be concave on the inner face and convex on the outer. The pouches are not circular in outline, but more nearly elliptical, being elongated dorso-ventrally. The gill, as a whole, has two faces and four borders—superior, inferior, anterior, and posterior. The anterior and posterior are usually indented so as to be slightly concave, instead of convex. The afferent gill passage enters at the middle of the concave *inner* wall of the gill. (Fig. XIX.)

The efferent gill passage is given off from about the center of the convex *outer* wall. (Fig. X.) The line through these openings I shall call the axis of the gill. The internal anatomy is complex. The mucous membrane of the inner walls is folded to form a number of plates which are parallel to the axis of the gill and extended radially toward the center. (Fig. IX.) There are about twenty large plates, and a large number of smaller ones. The latter extend only a short distance in from the wall, and fill in the spaces between the bases of the other gill plates. Each plate is thrown into folds, only moderately near the base, but to an extraordinary degree of complexity toward the center. In this way a large amount of respiratory surface is developed. The free central margin, like the attached base of the plate, is strong and only slightly branched. These parts seem to serve merely as supports for the extremely thin respiratory leaflets. The inner surface of the gill wall, and the thicker supporting parts of the gill plates are covered with a stratified epithelium. The delicate respiratory leaflets are covered with a thin pavement epithelium. Next to the epithelial membrane occurs a small amount of connective tissue surrounding the blood vessels. Externally, the wall of the gill pouch is composed of a double layer of striated muscle — the external layer of *circular* fibers, the internal of *longitudinal* fibers (parallel to the axis). Surrounding the muscular layer is a thin serous membrane, which lines the lymphatic peri-branchial spaces.

The general distribution of the blood vessels in the gills is as follows: The *afferent branchial artery* of each gill passes under the lower margin of each gill pouch, then upward over the convex outer gill wall, which it enters just below the external gill passage. Some small twigs are given off which supply the gill passage and the muscles of the gill wall. The afferent artery then divides into two branches which surround the opening of the gill-passage, forming an irregular "ring vessel." From this "ring vessel" several radial vessels, often dilated into sinuses, are given off which pass within the gill wall toward the peripheral margin. Branches are given off which extend along the attached margin of each gill plate, beneath the muscular layers of the gill wall. From these branches numerous smaller vessels pass directly into

the gill plate. Their general direction is parallel to the axis of the gill, and perpendicular to the walls of the gill pouch. These smaller vessels break up into capillaries, which ramify between the thin epithelial walls of the respiratory gill leaflets. In this region an extensive capillary network is formed, and anastomoses between the larger vessels are also common. Toward the opposite (*i. e.* the inner) attached edge of the gill plate, and in the free central margins, the capillaries again unite to form larger vessels. These efferent branchial vessels converge on the inner wall of the gill pouch in much the same way as they are distributed in the outer wall. They unite under the muscular layer into sinuses and vessels which finally unite to form the efferent branchial artery of each gill pouch. This vessel leaves the gill wall just above the internal gill passage. (Fig. XIX, ef, br.) A diagrammatic representation of the branchial circulation is shown in Figure XIII, which respresents the vascular distribution in a plane parallel to the gill axis. Figure IX shows a drawing of a section of an injected gill made perpendicular to the axis of the gill, and near its center. The low magnification fails to give an adequate idea of the great complexity in the formation of the gill leaflets. Figures VIII and XIV represent small portions of these leaflets magnified to show the capillary vessels, which are composed of a single layer of epithelial cells. The larger vessels have walls composed of three layers,—an outer layer of connective tissue, a middle layer of circular muscle fibers, and an inner simple endothelial layer.

The *efferent branchial arteries* (Figs. XVIII, XIX, XX, ef, br) arise from the inner face of each gill pouch, just above the internal gill passage (gpi). Each efferent vessel extends upward and inward toward the median line. In the posterior region each vessel ascends just behind a "gill constrictor" muscle, then turns forward immediately *above* it and joins the overlying common carotid just anterior to the muscle. There are never *two* efferent vessels for each gill-pouch, as is commonly the case in *Bdellostoma forsteri*. All the efferent branches of each side open into the corresponding lateral common carotid.

General Arterial System.

The *common carotid arteries* (right and left) posteriorly extend longitudinally along each side above the gills and beside the pharynx. (Figs. XVIII, XIX, XX, Car.) Externally, they connect with the efferent branchial arteries; and internally, by means of from four to seven short commissural vessels (comv) on each side, they communicate with the median dorsal aorta. These commissural vessels usually arise nearly opposite the fourth or fifth to the eighth or tenth pairs of gills. Posteriorly the common carotids are connected with the dorsal aorta nearly opposite each other, and a short distance behind the last pair of gills. Anteriorly they continue forward on each side of the pharynx, giving off numerous small twigs to this organ. Each carotid also supplies the club muscle with several branches. The most posterior pair of these branches seem to supply only that portion of the muscle connected with the longitudinal *retractor* fibers. The remaining branches supply the circular *constrictor* portion. The branches to the "club-muscle" run in the sheet of connective tissue which connects the muscle to the dorsolateral body wall on each side.

Just behind the cartilaginous "pharyngeal basket" of the branchial skeleton, each common carotid divides into two branches, the *external* and *internal* carotid arteries. Each external carotid passes forward and downward around and outside the pharyngeal basket and runs forward along the outer margin of the basal plate. Near the junction of the posterior with the anterior segments of the basal plate, a small branch is given off which passes upward and inward to the ligament attaching the dental plate (*ramus lingualis*). This branch supplies the dental plate but apparently not the muscles moving it. The main trunk of the external carotid then passes forward along the external margin of the basal plate on each side giving off small twigs to the lateral walls of the skull. Anteriorly it breaks up into a number of small branches, which supply the muscles and integument in the tentacular region.

Each *internal carotid* continues inward and forward just above the pharynx. (See Figs. XVIII and XX.) A rela-

tively large lateral branch is given off on each side which runs forward and supplies the muscles in the lateral region of the head. In one instance I traced this vessel (on the left side), forward under the lateral trunk muscles just outside the skull wall, under the hyoid arch, and out into the orbital region, sending a branch out to the skin, in the fibrous band of connective tissue just below the eye. The main trunk of the internal carotid joins the corresponding vessel of the opposite side in the median line just below the notochord and in front of the supra-pharyngeal plate. (See Fig. XX.)

The *vertebralis impar* (v), formed by the junction of the internal carotids, runs forward a short distance in the median line beneath the notochord, giving off branches to the brain and cranial wall. Passing below the cranium, just behind the pituitary sac, it divides into two lateral branches, right and left, which run forward on each side of the base of the cranium to the nasal and anterior head region.

The *anterior dorsal aorta* (Figs. XVIII, XIX, XX, Aa) is that portion of the median dorsal aorta which lies in, and in front of, the gill region. Posteriorly, it begins with the most posterior point of connection with the lateral carotids. It lies immediately above the pharynx, and below the notochord. In the gill region, the anterior dorsal aorta gives off four or five pairs of branches to the body wall (somatic branches). The posterior, three pairs of these usually pierce the overlying "gill constrictor" muscles. In the anterior gill region, the aorta curves slightly to the right, and continues forward beneath the right side of the notochord. In one instance it turned first to the left, ran forward two or three somites, then passed over to the right and forward as usual.

Anterior to the gill region it gives off in its course seven or eight pairs of somatic branches to the adjacent segments of the body wall. In general, an artery is given off to each alternate myoseptum on each side. Each somatic vessel divides into two branches, dorsal and ventral, whose course is the same as that of those to be described in the abdominal region (see Fig. XV). There are some variations in the distribution of the branches of the anterior dorsal aorta,

however. The arteries, like the corresponding myotomes, are not arranged in bilateral symmetry. The branches are given off *alternately*, especially in the anterior region. (See Fig. XX.) A short distance behind the junction of the internal carotids, the anterior dorsal aorta crosses over and joins the left internal carotid, just behind the origin of the lateral branch.

The *posterior dorsal aorta* (Figs. XII, XV, XVIII, XIX, XX, Ao), is the posterior continuation of the same vessel which anteriorly forms the anterior dorsal aorta. Beginning behind the junction with the lateral carotids, the posterior dorsal aorta gives off branches as follows:

(*a*) A pair of *somatic branches*, and usually a mesenteric twig to the intestinal wall.

(*b*) Twigs to the right and left *pronephros* (pnl, pnr). These may come off as separate twigs, but usually arise in common with somatic branches (Fig. XIX).

(*c*) The *coeliac artery* is a relatively large vessel. It occasionally gives off a twig to the left pronephros. It then passes downward between the sinus venosus and the alimentary canal (to which it gives off a small branch). The coeliac artery then proceeds along the common bile duct to the gall-cyst, which it supplies. Then it divides into two terminal vessels, anterior and posterior, which pass along the bile ducts to the anterior and posterior lobes of the liver. Here they break up into capillaries which supply these structures.

(*d*) *Mesenteric arteries* (Figs. XII, XV, XVIII, mes) are given off ventrally, which pass downward between the right and left posterior cardinal veins, in the mesentery, to the intestinal wall. Just above the intestinal wall they usually divide, one branch going to the right, the other to the left side of the intestine. Both branches pass to the left of the supra-intestinal vein, but pass one on each side of the vagus nerve, which lies in the median line just above the intestinal wall. There are about thirty mesenteric arteries, and they arise in a somewhat irregular manner. Often, however, they arise in couples, one a short distance behind the other (See Fig. XII).

(*e*) The *somatic arteries* arise regularly along the entire length of the dorsal aorta, anterior and posterior (Figs. XII,

XV, XVIII, XX, s). The somatic arteries, as a rule, alternate with the somatic *veins* on each side. (Fig. XII.) Those of the right and left sides are sometimes in pairs, opposite each other, but usually alternate, always corresponding to the arrangement of the myotomes on each side. The somatic arteries from the *anterior* dorsal aorta arise independently. Those from the *posterior* dorsal aorta usually arise by a short trunk in common with one or more renal branches (Fig. XII). Each somatic artery passes above the mesonephros, supplies it with one or more twigs, and then divides into two branches. (See Fig. XV.) The *dorsal* branch passes directly upward beside the notochord, supplying the lateral trunk muscles, and sending branches into the neural canal to supply the spinal cord. Then it passes up in the median longitudinal septum above the neural canal. It passes out to the skin of the dorsal region through the sheet of connective tissue which fastens the skin to the body wall.

The *ventral* branches of the somatic arteries correspond to the *intercostal vessels* of the higher vertebrates. (Figs. XII, XV, ic.) They pass outward along the roof and sides of the peritoneal cavity, between the lateral trunk muscles and the peritoneum. They pass along the septa between the myotomes, giving off many minute twigs to the adjoining muscles. (See Figs. XII, XV, ic.) Each "intercostal" passes along with (anterior to) the corresponding intercostal nerve (sn). After passing between two slime glands, which it supplies, each intercostal vessel gives off irregular branches to the ventral rectus trunk muscle in the vicinity. The end piece of each vessel passes out into the skin in the neighborhood of the slime glands, and is distributed to the integument of the ventral and lateral regions of the body.

(*f*) *Renal branches* are supplied segmentally to the mesonephros along each side of the aorta. A portion of these are shown in Figure XII, (r). (cfr. also Figs. XVIII and XX.) These renal branches supply the segmental glomeruli along the inner wall of the mesonephros. The glomeruli correspond to the myotomes only in a general way, and not exactly. Usually two glomerular vessels, and one or more twigs to the dorsal and inner walls of the mesonephros, arise from a common trunk with a somatic branch. There is

much variation in this respect, however. Sometimes a somatic and one renal vessel arise together, and sometimes the renal vessels arise independently.

(*g*) The *genital branches* (Figs. VII, XVIII, XX, gen) arise from all the mesenteric arteries in the region of the testis in the male, and the ovary in the female. Occasionally branches arise independently from the dorsal aorta. The genital branches pass out in the genital ligament (a special fold on the right side of the mesentery). Soon after entering this fold the genital vessels, for the most part, unite to form a longitudinal commissural vessel. (Fig. VII.) From this vessel a large number of smaller vessels run out toward the testis or ovary, branching and anastomosing freely. A capillary network is formed in the membrane surrounding each ovum, or lobule of the testis.

Behind the cloaca, the aorta continues immediately below the notochord in the median line, but here, as might be expected, only the somatic branches are given off. On reaching the median ventral plate, the aorta divides into a right and a left branch, each of which passes backward on the corresponding side of the plate. Lateral branches are given off to supply the muscles and integument of the caudal region. In the caudal fin, small vessels run out distally corresponding to each fin ray.

General Venous System.

The *veins* of the Bdellostoma may be included under two separate systems—the *general* system, and the *portal* system. The general venous system is larger, including all those veins through which the blood flows into the sinus venosus. (Figs. X, XI, XVII, XVIII, S.) Anteriorly where it empties into the auricle, the sinus is narrow, and receives the *inferior jugular* vein (jv). Posteriorly, behind the auricle, the sinus is dilated, and receives on the left, the *left anterior cardinal vein* (acl.) anteriorily, and the common cardinal vein (pcc) posteriorly. On the right side enter the anterior and posterior *hepatic veins* (ha, hp).

Beginning with the general venous system in the head region, we find the *superficial anterior cardinal vein*. (Figs.

XVII, XVIII, scd) arising on each side of the head. It leaves the cranium just dorsal to the corresponding vagus nerve. It passes backward alongside the vagus, between the lateral trunk muscles, and the constrictors of the pharynx. In this region it receives the first eight or ten somatic veins. These somatic veins, like the somatic arteries (with which they alternate), arise from the skin and trunk muscles the entire length of the body. They correspond exactly to the somatic veins of the abdominal region shown in Figure XV, (s). They are each composed of a very short terminal trunk which is supplied by two branches, (1) a *dorsal* branch which collects the blood from the dorsal region of the integument, the spinal cord, notochord and muscles of the vicinity. It descends vertically at the side of the notochord, and on reaching the ventral surface of the dorsal body wall, joins with (2) the *ventral* branch, or "*intercostal*" vein. The intercostal veins, like the intercostal arteries, are distributed to the integument of the ventral and lateral regions of the body, and the ventral rectus muscle. In the gill region, the intercostals receive, in the region of the slime glands, occasional "pleural" branches from the connective tissue. Then after collecting the blood from the two adjacent slime glands, it passes between these along the intermuscular septum of the myotomes, on the ventral surface of the dorsal and dorso-lateral body walls. The intercostal veins lie just in front of the corresponding intercostal nerves. As before mentioned, the intercostal veins usually alternate with the intercostal arteries (Figs. XI, XII, XV, XIX, ic), especially in the abdominal region. In the pharyngeal region the arrangement is less regular, there being often two adjacent arteries or veins, and occasionally both an artery or vein on *one* intermuscular septum. (Fig. XIX.) After receiving the somatic veins from the head region, the superficial cardinal pierces the constrictor muscle and joins the *deep cardinal* vein.

The *deep anterior cardinal* vein (Figs. XVII, XVIII, dcd) arises from the integument and muscles of the anterior head region. It passes on each side between the pharynx and hyoid arch (just below the posterior process), then directly backward alongside the pharynx, internal to the constrictors,

receiving branches, and passing under the first branchial arch, but over the second. About 2–3 cm. behind the second arch it is joined by the *superficial cardinal* to form the *common anterior cardinal* vein.

The *common anterior cardinal* (or jugular) veins, right and left (Figs. XVII, XIX, acr, acl), pass backward and beside the pharynx, just external to the corresponding carotid artery, and internal to the vagus nerve. They receive four sets of branches: (1) somatic veins from the body wall; (2) pharyngeal branches, (ph), numerous small twigs from the wall of the pharynx; (3) "club-muscle" branches, from the "club-muscle;" (4) "pleural" branches from the connective tissue in the pharyngeal region. Anteriorly, the courses of the right and left anterior common cardinals are similar. Behind the "club-muscle," however, they are quite different.

The *left anterior cardinal* continues in the same general direction backward beside the vagus, and above the gills. It receives the usual somatic branches, and also a few "pleural" twigs from the connective tissue surrounding the gill pouches. It also occasionally receives twigs from the walls of the gill passages and oesophago-cutaneous duct. Posteriorly (Fig. XI, acl), it forms a slight projection from the roof into the left pericardial cavity, as before described. It passes between the left pronephros, from which it receives a twig, and the alimentary canal, and empties into the antero-lateral angle of the dilated posterior portion of the sinus venosus.

The *right anterior cardinal*, on the other hand, toward the posterior end of the "club-muscle," leaves the pharyngeal wall, passes downward toward the posterior end of the "club-muscle," and crossing over toward the median line, empties into the *inferior jugular* vein. (Fig. XIX, jv) The remaining area corresponding to that supplied by the left anterior cardinal on the other side of the body is supplied by the portal system.

The *inferior jugular vein* (Figs. X, XVII, XVIII, jv) arises from the posterior end of the "club-muscle," from which it emerges on the ventral surface. It passes backward a little to the left of the median line, immediately over the ventral body wall. After receiving the right anterior cardinal

vein, it continues backward a little below and to the left of the median ventral aorta. (Fig. X.) It receives a varying number of branches from the body wall. It also receives several small "pleural" twigs from the connective tissue and gill passages, including the oesophago-cutaneous duct and the adjoining pharyngeal wall. Finally, the inferior jugular vein empties into the anterior end of the sinus venosus, just in front of the sinu-auricular aperture.

The *posterior cardinal veins* arise in the caudal region from small twigs which form two small veins. These lateral veins accompany the arteries on each side of the cartilaginous median ventral plate in the caudal region. (Fig. XVII.) They unite to form the *median caudal vein* (caud), which runs forward immediately beneath the caudal artery. The caudal vein, at its posterior end, is dilated to form a small sinus just in front of the median ventral plate. Laterally, the caudal vein receives, on each side, the somatic veins of the caudal region.

Anteriorly, in the cloacal region, the caudal vein divides into two veins, the *right* and *left posterior cardinal veins.* (Figs. XI, XII, XV, XVIII, XIX, pcr, pcl.) These vessels run parallel with each other, just below and on each side of the posterior dorsal aorta. The right posterior cardinal is much smaller than the left. (See Figs. XII, XV, XVII.) Each lies internal to and in contact with that side of the corresponding mesonephros which faces toward the median line. The posterior cardinals are joined by a large number of short transverse commissural vessels (about twenty-five in all). They are not placed at regular intervals, but are more numerous in the posterior region. They vary in size, being usually about as wide as the *right* cardinal vein. The posterior cardinals receive two sets of branches: (1) the renal branches; (2) the somatic veins.

The *renal branches* (see Fig. XII), appear to arise, for the most part, on the ventral surface of the mesonephros. They collect together and form small twigs, which run across toward the median line and empty into the corresponding posterior cardinal vein. These renal veins are somewhat irregularly distributed, but traces of their original segmental arrangement are easily recognized.

The *somatic* veins have already been described in a general way. Those of the abdominal region pass dorsal to the corresponding mesonephros (receiving no branches from them), and empty into the corresponding posterior cardinal vein.

The posterior cardinals receive no veins from the intestine. In one instance only I observed a branch from the testis running upward into the right posterior cardinal vein.

Anteriorly, a short distance behind the heart, the right and left posterior cardinals unite again to form the unpaired *posterior common cardinal vein* (Fig. XVII, pcc), which passes forward on the left side, and empties into the posterior end of the sinus venosus.

The *sub-intestinal vein* (Figs. XI, XV, XVII, XVIII, sub. int.) arises from the ventral wall of the intestine toward the anterior end. It passes forward along the median ventral line of the intestinal wall, and on reaching the hepatic ligament, passes down along its posterior margin to the posterior lobe of the liver. (Fig. XI.) In some specimens it passes through the tissue of the liver for a considerable distance, but in others it runs along the surface, within the serous membrane. It passes behind the liver, and runs forward on its ventral and external aspect. It receives branches from the posterior lobe of the liver, and becomes the posterior hepatic vein (hp). As such it passes upward, parallel and near to the bile duct of the posterior lobe. It becomes very much widened, and finally empties into the posterior end of the sinus venosus, opposite the common posterior cardinal vein.

The veins of the anterior lobe of the liver converge to form the *anterior hepatic vein*, which lies on the dorsal surface of the lobe. (Figs. XI, XVII, XVIII, ha.) This vein runs forward and upward, emptying into the left side of the sinus venosus, a little behind the sinu-auricular opening.

There is also apparently a small vein running in the ligament between the anterior end of the posterior lobe, and the posterior end of the anterior lobe. The veins from the gall cyst, as will be seen, join the portal system, and will be described there.

THE PORTAL VENOUS SYSTEM.

The portal venous system includes the portal vein and all the vessels which flow into it.

The *anterior portal vein* (Figs. XVII, XVIII, XIX, ap) arises in the right branchial region, a little in front of the posterior end of the "club-muscle." (Fig. XIX.) It lies just below and to the right of the notochord, and receives the somatic veins from the right side in the branchial region. A few scattering venous twigs from this region also pass across into the inferior jugular vein. The anterior portal continues backward into the fold (portal septum), separating the inner and outer chambers of the right pericardial cavity, as previously described. It passes between the alimentary canal and the right pronephros, and opens into the roof of the portal heart near the anterior end. The entrance is guarded by a pair of thin membranous valves, semi-lunar in shape, one anterior and one posterior. (See Fig. XVI, ap.) Just before entering the portal heart it receives a branch which is made up of a twig from the pronephros, and (often) two or three somatic veins lying opposite and posterior to the portal heart. In one instance, I observed an anastomosis between this vein and a somatic vein emptying into the right posterior cardinal vein.

The *supra-intestinal* vein (Figs. XI, XII, XV, XVII, XVIII, XIX, supr. int.) receives the blood from the entire intestinal wall, excepting the floor in the anterior region. It runs forward just above the intestine a little to the right of the median line, within the mesentery. It lies to the right of the vagus nerve and the mesenteric arteries. In the region of the reproductive organs the supra-intestinal vein receives several *genital veins* which descend in the mesentery. These veins are formed by the plexus of small venous twigs in the special genital fold of the mesentery (Figs. XII, XVIII, gen). On reaching the pericardial region, the supra-intestinal vein turns to the right side of the intestine. Here it receives the *cystic vein* (Fig. XIX, cv), which is made up of branches from the gall cyst. The supra-intestinal vein then passes through the pericardio-peritoneal foramen, beside the intestine, and below the right mesonephros. It then crosses

the roof of the outer chamber of the right pericardial cavity just below the right vagus nerve, and enters the roof of the portal heart near the posterior end. (See Fig. XVI, supr int.) The slit through which the blood enters is diagonally placed, and guarded by a pair of semi-lunar valves, like those of the anterior portal.

The *portal heart* (Figs. X, XVI, XVII. XVIII, XIX, H.) lies in the pericardial fold which forms the septum in the right pericardial cavity. It is an elongated sac (1-2 cm. in length), somewhat irregular in shape and variable in size. It stretches diagonally across the pericardial cavity, and lies nearly opposite the ventricle (cf. Fig. X). Anteriorly it receives the anterior portal vein; toward the posterior end it receives the supra-intestinal vein. Both these enter dorsally. At its posterior extremity the portal heart empties into its efferent vessel, the *common portal vein*. The opening into the common portal vein is guarded by a pair of strong semi-lunar valves (Fig. XVI, cp), which are placed laterally, and like the other valves previously described, prevent any reflux of blood during the circulation.

Johannes Müller was mistaken in his statement that no muscle fibers exist in the portal heart of Bdellostoma.* The wall is quite muscular, fully as much as that of the auricle. As in the latter, the inner surface of the wall of the portal heart is made irregular by muscular and fibrous trabeculæ, which project from the surface. The muscle fibers are *distinctly striated*, and their nuclei seem to lie on the sides of (not within) the contractile fibers.

The *common portal vein* (Figs. XVII, XVIII, XIX, cp) continues backward and inward toward the median line. It passes above the anterior lobe of the liver, to which it gives off ventrally a large branch which descends almost vertically alongside the hepatic duct of the anterior lobe. (XI, cpa). The main trunk of the common portal vein then crosses the median line to the left side and passes backward and downward alongside the hepatic duct of the posterior lobe. (Fig. XI, cpp.) About the center of the dorsal surface it enters

*Vergl. Anat. der Myxinoiden (1834). Later Müller observed the pulsations of the portal heart in living Myxine. Untersuchungen über die Eingeweide der Fische (1842).

the posterior lobe and breaks up into capillaries in the tissue of the liver.

I have observed in several cases a marked tendency for the injected carmine gelatine to escape from the blood vessels into the surrounding lymphatics, which are very numerous and extensive. These lymphatic spaces, especially the subdermal spaces in the caudal region, and the peri-branchial spaces around the gill pouches, are usually found more or less injected, although the blood vessels show no signs of overdistension. The lymphatic spaces around the vessels in the gill itself are also often filled. This condition may be interpreted as indicating that the capillary walls are unusually weak and permeable, so that the injected liquid passes through them, carrying blood corpuscles with it. That this process is not normal is shown by the absence of red blood corpuscles from these lymphatic spaces in life, and in uninjected specimens.

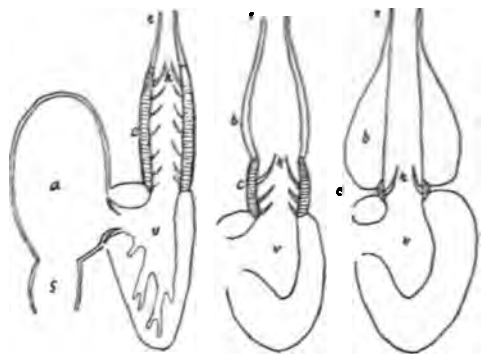
Remarks on Comparative Anatomy of Bdellostoma.

The communication of the pericardial cavity with the peritoneal cavity through the pericardo-peritoneal foramen is primitive. The heart, which is a specialized portion of the primitive sub-intestinal vessel, always develops at first in the anterior end of the general peritoneal cavity. In all adults, however, a special pericardial cavity is formed. In Petromyzon, whose pericardial sac is enclosed in a cartilaginous pocket, the separation is complete. In the larval Ammocœtes, however, there exist two larval pericardio-peritoneal foramina, one on either side. Communication between pericardial and peritoneal cavities exists also in Elasmobranchs and Ganoids, but only during embryonic life in all higher vertebrates.

Although its embryological development is not yet worked out, the sinus venosus doubtless at first receives a right and left *ductus Cuvieri*, like Petromyzon (Goette), and higher forms. The right ductus has probably been lost altogether in a manner which will be discussed later. The left ductus Cuvieri has apparently fused with the sinus venosus, and is represented by the external portion of the posterior expanded

division of the sinus, which still receives the right anterior and posterior cardinals.

In the absence of a contractile valved *conus arteriosus*, Bdellostoma and all the Cyclostomata resemble the Teleosts more than the Elasmobranchs. (See text figures A, B, C.)



A B C

A, Elasmobranch.
B, Ganoid.
C, Teleost.
s, sinus venosus.
a, auricle.
v, ventricle.
c, conus arteriosus.
b, bulbus arteriosus.
t, ventral aorta.
k, valves.
(From Boas's Zoology.)

In this respect the Bdellostoma is probably not primitive, since in the Sharks and Ganoids there is clearly a tendency to a reduction in the number of the valves and the size of the conus.*

Contrary to Müller's statement (Vergl. Anat. der Myxinoiden, pp. 180), the bulbus aortæ is *not* entirely devoid of muscular fibers. As in the arteries in general, there is a small amount of plain muscle fibers mixed with the thick layer of elastic fibers. The bulbus is evidently not contractile, however, in the ordinary sense of the word.

*It is quite possible, however, that the absence of a conus represents a condition more primitive than the Elasmobranch. No valved conus appears during the development of Petromyzon.

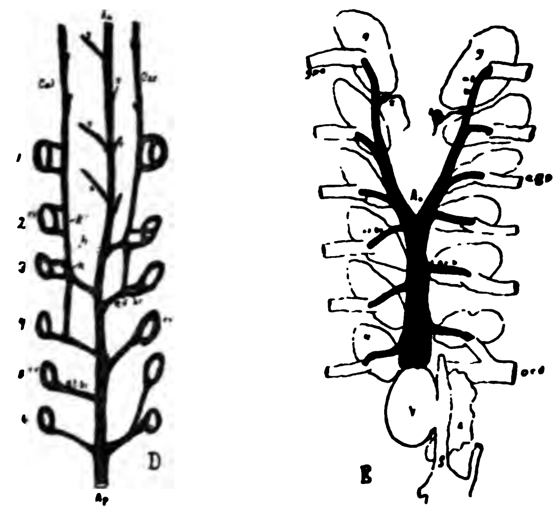
Variations from the structure of the typical ventral aorta, as previously described, are very common. As an extreme instance, I may mention a case mentioned by Müller, in which the ventral aorta, immediately after leaving the heart, divided into two branches from which all the afferent branchial arteries arise.

With respect to the "ductus Botalli," Müller noted the following in *Bdellostoma forsteri*:" "Ehe wir die Gefässe der Myxinoiden ganz verlassen, müssen wir noch einer Beobachtung gedenken, welche auf einen Entwickelungszustand des Gefäss-systems der Myxinoiden einiges Licht wirft. Ich habe nämlich bei dem grossen Myxinoid vom Cap wiederholt die Reste zweier ductus Botalli bemerkt, welche früher ohne Zweifel die *arteria branchialis* mit dem Arterien system in Verbindung setzten, jetzt aber ganz feine fadenartige Stränge bilden, deren Ursprung aus der *arteria branchialis* und Ende in Arteriensystem des Körpers aber noch hohl sind. Dieser Faden entspringt aus dem Aste der Kiemenarterie zur vordersten Kieme, in gleicher Weise auf jeder Seite. Bei seinen Ursprung ist er ansehnlich dick, conish und hohl, die Fortsetzung ist aber sehr fein sie geht vorwärts aufwärts gegen die Carotis hin, wo diese aus den vordern Kiemenvenen entsteht, hier erweitert sich der Faden wieder, wird wieder hohl und senkt sich in die Anfang der Carotis ein. Aus diesem hohlen Ende des Fadens gehen einige feine Zweige zu den Pleuren ab. Diese Anordnung fand ich in gleicher Weise bei mehreren grossen Exemplaren von *Bdellostoma forsteri.* Ich habe sie auch bei den *Myxinen* gesehen. Diese obliterirten ductus Botalli waren offenbar früher weite Aortenbogen von dem *truncus arteriosus* des Herzens zu den Carotiden und von diesen weiter zur Aorta." (loc. cit., pp. 191.)

I have already described the same structures found in *Bdellostoma dombeyi.* In addition to the observation of Müller, I have added that a spheroidal or flattened mass of connective tissue is found attached to the "ductus" a short distance from its origin. This body is larger and more saccular in appearance in *Bdellostoma forsteri.* (See text figure E, z), and evidently may be interpreted as the rudiment of the *gill pouch* corresponding to the obliterated branchial artery. A similar ductus Botalli from the first branchial

artery is found in certain Caducibranchiata. In these cases, a "rete mirabile" persists in the course of the ductus, and represents the obliterated gill. (Balfour, Comp. Embryol. Vol II.)

Since the "ductus Botalli" is a constant feature in all specimens of *Bdellostoma* examined, its significance lies in



D, efferent branchial system of *Bdellostoma forsteri*, dorsal view.
E, heart and afferent branchial system of *Bdellostoma forsteri*, ventral view.
Ap. posterior dorsal aorta.
Aa, anterior dorsal aorta.
Car, right carotid.
Cal, left carotid.
ef. br, efferent branchial artery.
rv, ring vessel of gill passage.
S, sinus venosus.
A, auricle.
V, ventricle.
Av, ventral aorta.
afb, afferent branchial artery.
z, body on "ductus Botalli."
g, gill pouch.
gpe, external gill passage,
ocd, oesophago-cutaneous duct.

the fact that even in the 13-gilled forms, we have to do with a *reduction* rather than an *increase* in the *primitive number of gills*. The embryological development, according to Price (Some Points in the Development of a Myxinoid. Verhl. der Anat. Ges., 1896), renders this conclusion certain. A large

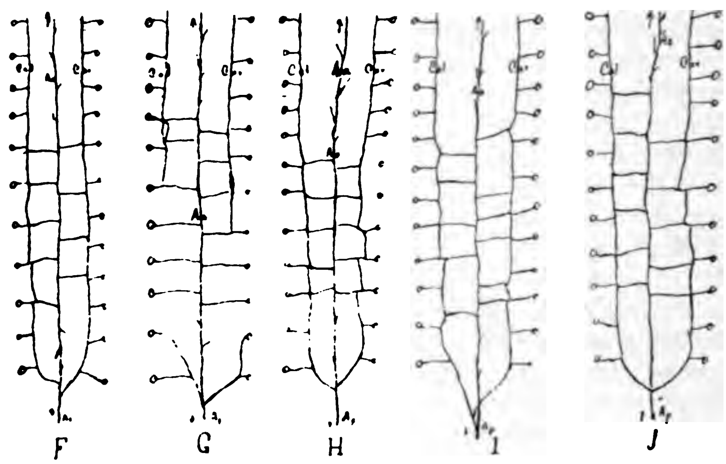
number of gill pouches (possibly thirty-five pairs) arise during the course of development. Of these, only the posterior 10–14 pairs remain to form the permanent gills of the adult.

The distribution of branchial vessels, one to each gill cleft (gill pouch), is a character in which the Myxinoids differ from all other Vertebrates. Even in Petromyzon, each afferent and efferent vessel is distributed to the *hemibranch* of *two different pouches*, the gill arteries corresponding to *gill-arches* rather than *gill clefts*. It is probable that the Myxenoid condition is not primitive, although the embryological development is not known. A probable explanation of the manner in which this unique condition has been derived from the primitive arrangement is suggested by an examination of the efferent branchial vessels and their connections in *Bdellostoma forsteri* (see text figure D.) Here we find, usually, *two efferent branchial vessels* (ef, br) arising from the ring vessel (rv) which surrounds the gill passage on the wall of the gill pouch. These efferent vessels unite with the lateral carotid vessels, and with the dorsal aorta by anastomoses. This is an interesting intermediate stage between the arrangement of the vessels in *Bdellostoma dombeyi* (see Plate III, Fig. XX), and the ordinary vertebrate type. Referring again to text figure D, suppose, for example, we take afferent vessels from gill 3. If we fuse the two vessels together (which is almost accomplished in the sixth gill, right side), or obliterate one of them, we get *one* efferent vessel for each gill, as in gills 4, 5, and 6, left side. This is the condition in *all* the gills of *Bdellostoma dombeyi*. But if we break the connection at k, gill 3, and k^1, gill 2, and at the same time connect the artery between them with the dorsal aorta by a vessel, h (dotted outline), this vessel, h, would be an *efferent branchial artery* of the *usual vertebrate type*. It would receive the blood from the posterior hemi-branch of gill 2, and the anterior hemi-branch of gill 3. I have no doubt that this very relation would be found as a variation, if a large number of specimens of *Bdellostoma forsteri* were examined.

A consideration of the extreme variability of the blood vessels in *Bdellostoma* renders this explanation all the more probable. To give a more adequate idea of the nature and extent of variation, I have made diagrams to show the rela-

tion between the efferent branchials, carotids, and dorsal aorta, as I found it, in five specimens of *Bdellostoma dombeyi*, taken entirely at random.

The variations apparently have no constant relation to the size or sex of the specimen. The number of efferent vessels, of course, varies with the number of gills.



F, G, H, I, J. Diagrams of the efferent branchial arteries and their connections (dorsal view) in Bdellostoma dombeyi. Lettering same as in plate figures (q. v.)

As a result of his studies of the blood vessels of Chlamydoselachus, Dr. Ayers (Morphology of the Carotids, Bul. Museum. Comp. Zool., Harvard. Vol. XVII, No. 5, p. 211), reaches the following conclusion: "It is likewise obvious that the carotid vessels cannot strictly be said to arise from, or constitute the remains of, any particular pair of aortic arches, but represents all that is left of the commissural trunk from the most anterior arch of the ancestral form to the most anterior arch of any existing form." Bdellostoma and the Myxinoid type would seem to indicate rather the origin of the carotid arteries from a longitudinal trunk connecting *all* the efferent branchial vessels on each side.

I have not as yet been able to work out fully the distribution and homologies of the blood vessels in the head region. This problem, on account of its difficulty and importance, is reserved for a special paper. I may mention, however, that

the extension forward of the sub-chordal dorsal aorta into the head region as the *vertebralis impar* (*vertebralis impar capitis*, of Müller; *cranial aorta*, of Ayers) is probably a primitive character. This vessel occurs in Chlamydoselachus, as well as the Cyclostomata.

Müller describes a vein in Bdellostoma forsteri which runs from the right pronephros to the posterior cardinal. Only once have I found a similar vessel in Bdellostoma dombeyi. The vein which he describes from the intestine to the common posterior cardinal is also apparently lacking in Bdellostoma dombeyi.

In Petromyzon, as in most Vertebrates, but unlike Bdellostoma, the genital veins open into the posterior cardinals instead of the supra-intestinal vein. The difference in size between the right and left posterior cardinals is only one example of the great asymmetry of the venous system which is so characteristic of Bdellostoma.

The sub-intestinal vein* is the homologue of the large ventral vein in Amphioxus, and the embryonic sub-intestinal vein of higher vertebrates. Judging from the development of Petromyzon (Goette, Entwickelungsgeschichte des Flussneunauges) and other forms, the sub-intestinal vein at first probably supplied the entire intestine, and was continued posteriorly into the caudal vein. The connection of the caudal vein with the posterior cardinals is very probably here, as elsewhere, a secondary arrangement. The reduction in the size and extent of the sub-intestinal vein is correlated with the development of the supra-intestinal vein. It is interesting to note that in Bdellostoma the sub-intestinal vein *does not break up into capillaries in the liver* to form a portal system, although it runs over the surface of, and even *through* the liver tissue. This is evidently an extremely primitive character, for the same relation is found in the early *embryonic* development of the same vessel in Petromyzon (Goette, loc. cit.), and all higher Vertebrates. According to Willey ("Amphioxus and the Ancestry of the Vertebrates") it is yet doubtful whether the sub-intestinal vein in Amphioxus forms a *true* capillary portal system, or merely passes through

*It is a remarkable fact that the presence of this vein in Bdellostoma has apparently been overlooked heretofore by all observers, including Johannes Müller.

a system of small sinuses *outside the liver proper*. In all Vertebrates above Bdellostoma (including Petromyzon), the sub-intestinal vein in the adult forms a part of the portal system.

The inferior jugular vein when median and *unpaired*, as in Petromyzon and some of the higher fishes, always empties into the sinus venosus. When *paired*, as in other fishes, it empties into the ductus Cuvieri on each side. Müller recognized that the posterior end of the right anterior cardinal represented the inferior jugular of other forms, but did not describe it as such. According to him (Vergl. Anat. der Myxinoiden, p. 209), the inferior jugular always originates in the hyoid arch and the under side of the operculums. It also commonly receives branches from the muscles of the pharynx, *venæ branchiales inferiores* and *venæ nutritiæ* of the gill arches. Its origin in Myxinoids is dorsal to the ventral aorta, but its course is ventral to it. The large "club-muscle," therefore, has a *double* venous supply. The " retractor " portion is supplied by the inferior jugular vein; the " compressor " portion by the lateral anterior cardinals (jugulars).

The anterior cardinals (or jugulars) of Bdellostoma agree in all essential respects with those in other fishes, excepting the posterior end of the right cardinal. From the probable ancestral form, as represented in Elasmobranchs (viz., symmetrical cardinals, anterior and posterior, flowing into right and left ductus Cuvieri on each side) the present arrangement in Bdellostoma may easily have arose as follows: 1. An anastomosis was formed between the right anterior cardinal and the inferior jugular, near the posterior end of the " club-muscle;" 2. An anastomosis of the posterior end of the anterior cardinal with the portal system; 3. An obliteration of the primitive anterior cardinal vessel *just behind* each of these anastomoses. Furthermore, by a union of the anterior ends of the posterior common cardinals, the blood was diverted from the *right* into the left *ductus* Cuvieri, and the right ductus disappeared entirely. The embryology of the cardinal veins, when worked out, will decide whether this is the true explanation of the present condition in Bdellostoma.

In no other fishes does the blood from the walls of the anterior body region pass into the portal system. It is said

to occur in some Testudinata and Amphibia, however. The portal system of Bdellostoma is also remarkable in being developed chiefly from the supra-intestinal vein, and in having no connection whatever with the sub-intestinal vein.

A well developed portal heart, contractile and supplied with a complete system of valves, so far as I know, occurs nowhere else among Vertebrates (excepting the closely related Myxine?). Contractile veins, however, are not uncommon.

I may sum up my conclusions in regard to the Comparative Anatomy as follows:

PRIMITIVE CHARACTERS IN THE BLOOD-VASCULAR SYSTEM OF BDELLOSTOMA.

1. Persistent pericardio-peritoneal foramen.
2. The simple tubular heart.
3. The large number (up to 14) of functional branchial vessels.
4. The origin of the carotid arteries from a lateral commissural vessel on each side connecting all the efferent branchial arteries.
5. The complete sub-chordal aorta (dorsal aorta) extending forward into the head region.
6. Segmental arrangement of the somatic and renal arteries and veins.
7. Frequent anastomosis between the posterior cardinal veins.
8. Persistent sub-intestinal vein which does not join the portal system.
9. The presence of an inferior jugular vein.
10. The contractility of the portal heart.

CHARACTERS SECONDARILY ACQUIRED.

1. The asymmetry of the venous system.
2. Distribution of branchial vessels to gill slits instead of gill arches.
3. The extension of the portal system into the territory of the right anterior cardinal vein.

4. The connection of the caudal vein with the posterior cardinals.

5. The presence of a well developed valvular portal heart.

EXPLANATION OF LETTERING USED IN FIGURES.

A, auricle.
Al, alimentary canal.
Av, ventral aorta.
Aa, anterior dorsal aorta.
Ap, posterior dorsal aorta.
BA, bulbus aortæ.
Car, right common carotid.
Cal, left common carotid.
H, portal heart.
I, intestine.
L, liver.
La, anterior lobe of the liver.
Lp, posterior lobe of the liver.
M, mesentery.
S, sinus venosus.
T, lobules of testis.
V, ventricle.

aha, anterior hepatic artery.
acl, left anterior cardinal vein.
acr, right anterior cardinal vein.
avv, auriculo-ventricular valves.
av, aortic valves.
af. br, afferent branchial arteries.
ap, anterior portal vein.
cv, cystic vein.
cm, "club-muscle."
clb, "club-muscle" branches.
cap, capillary network.
conv, connecting vessel.
cpa, anterior branch of the common portal.
cpp, posterior branch of the common portal.
coel, coeliac artery.
caud, caudal vessel.
cp, common portal vein.
d, dermal branches.
dcd, deep anterior cardinal.
ep, epithelium of the gill cavity.
ef. br, efferent branchial artery.
ext. car, external carotid artery.
gen, genital branches.
gb, gall cyst.
gpe, external gill passage.
gpi, internal gill passage.
gp, cavity of the gill pouch.
g, gill pouch.
ha, anterior hepatic vein.
hp, posterior hepatic vein.
i, inner (visceral) layer of the pericardium.
ic, "intercostal" vessel.
int. car, internal carotid artery.
jv, inferior jugular vein.
lbr, lateral branch.
mc, mesocardium.
mnr, right mesonephros.
mnl, left mesonephros.
mw, muscular wall of gill pouch.
my, myotomes.
mes, mesenteric arteries.
ntc, notochord.
o, outer (parietal) layer of the pericardium.
ocd, oesophago-cutaneous duct
pcr, right posterior cardinal vein.
pcl, left posterior cardinal vein
pcc, common posterior cardinal
ph, pharyngeal branches.
pnr, right pronephros.
pnl, left pronephros.
ptc, peritoneal cavity.
pcf, pericardio-peritoneal foramen.

pcv, . . pericardial cavity.
pha, . . posterior hepatic artery.
rbc, . . red blood corpuscles.
r, . . . renal branches.
spc, . . spinal cord.
sub. int, sub-intestinal vein.
scd, . . superficial anterior cardinal.
supr. int, supra-intestinal vein.
sn, . . . "intercostal" nerve.
sgl, . . slime glands.
sav, . . sinu-auricular valves.
s, . . . somatic vessels.
vv, . . . valves of portal heart.
vg, . . vagus nerve.
x, . . . "ductus Botalli,"

In figures IV, V, VI, red line indicates peritoneum; in all other figures—red, arteries; blue, veins; green, portal vessels.

EXPLANATION OF PLATES.

Plate I includes Figures I–IX.

Plate II includes Figures X–XVI.

Plate III includes Figures XVII–XX.

FIGURE I.— Heart of *Bdellostoma dombeyi* (×1). Dorsal view.

A, auricle. V, ventricle. S, sinus venosus. BA, bulbus aortæ. jv, inferior jugular vein. acl, left anterior cardinal. pcc, posterior common cardinal. ha, anterior hepatic vein. hp, posterior hepatic vein.

FIGURE II.— Heart of *Bdellostoma dombeyi* (×1). Ventral view. Lettering same as in Fig. I.

FIGURE III.— Heart of *Bdellostoma dombeyi* (×2). Showing a dorsal view of the ventral half of the auricle and ventricle, the dorsal half having been removed by a horizontal section.

sav, sinu-auricular valves. avv, auriculo-ventricular valves. av, aorta valves. Otherwise as in Fig. I.

FIGURE IV.— Diagram of cross section passing through the mid-abdominal region of *Bdellostoma*.

M, mesentery. A, alimentary canal. ptc, peritoneal cavity.

FIGURE V.— Diagram of cross section passing through the posterior lobe of the liver in *Bdellostoma*.

L, liver.

FIGURE VI.— Diagram of cross section passing through the ventricle and anterior lobe of the liver. Showing the relation of the pericardial cavity to the general peritoneal cavity.

pcf, pericardio-peritoneal foramen. pcv, pericardial cavity. o, outer or parietal layer of the pericardium. i, inner, or visceral pericardial layer. me, mesocardium. V, ventricle. Dotted line, pericardium.

FIGURE VII.— Testis of *Bdellostoma dombeyi* (×2), showing the arterial supply. The genital fold lies on the right side of the mesentery.

wS, mesenteric artery. qs, genital branches. T, lobules of testis. Ap, posterior dorsal aorta.

FIGURES VIII AND XIV.— Highly magnified portions of the smallest branches of a gill leaflet (×450).

cap, capillary wall. ep, epithelium lining gill cavity. rbc, red blood corpusles. con, connective tissue.

FIGURE IX.—Cross section of an injected gill pouch of *Bdellostoma* (×8). Taken perpendicular to the gill axis, about at the center.

Camera lucida outline.

mw, muscular wall of gill pouch. gp, cavity of gill, into which gill leaflets project.

FIGURE X.— Branchial region of *Bdellostoma dombeyi* (×1½). Ventral view. Body wall opened by a median longitudinal incision, and the lateral flaps folded back. Anterior lobe of the liver removed to expose heart. Arteries colored red. Veins blue.

Av, ventral aorta. af. br, afferent branchial arteries. x, on last afferent branchial artery indicates position of "ductus Botalli." ic, "intercostals" (arteries red, veins blue). S, Sinus venosus. jv, inferior jugular vein. acl, left anterior cardinal vein. supr. int, supra-intestinal vein. A, auricle. V, Ventricle. H, portal heart. Lp, posterior lobe of liver. gb, gall bladder. mnr, mnl, right and left mesonephros. pnr, pnl, right and left pronephros. pcf, pericardio-peritoneal foramen (dotted outline). sgl, slime glands. ocd, oesophago-cutaneous duct. cm, "club-muscle." gpe, spe, external gill passages.

FIGURE XI.—Lateral view of the viscera of *Bdellostoma dombeyi* left side, including ventral view of the left half of the body wall, which has been laid back (×1).

cpa, anterior branch of common portal vein. cpp, posterior branch of common portal vein. Jv, inferior jugular vein. acl, left anterior cardinal. ha, hp, anterior and posterior hepatic veins. cpa, cpp, anterior and posterior branches of common portal vein. ocl, left posterior cardinal. supr. int, supra-intestinal vein. sub. int, sub-intestinal vein. La, Lp, anterior and posterior lobes of the liver. pnl, left pronephros. mnl, left mesonephros. ic, "intercostal" vessels. Otherwise as previously.

FIGURE XII.— Mid abdominal region of *Bdellostoma dombeyi*, showing ventral view of the left side of the body wall, and a lateral view of the intestine and mesentery. The latter have been laid over upon the right side of the body wall, and the mesentery stretched out (×2).

r, renal branches. s, somatic branches (red, arteries; blue, veins). pcl, pcr, posterior cardinal veins, left and right. mes, mesenteric arteries. vg, vagus nerve. sn, "intercostal" nerve. Otherwise as previously.

FIGURE XIII.— Diagram of one half of a section through the gill pouch of *Bdellostoma*, parallel with the axis of the gill. Afferent vessels red. Efferent vessels blue.

af. br, afferent branchial vessel. ef. br, efferent branchial. cap, capillary network.

FIGURE XIV.—See Fig. VIII.

FIGURE XV.— Diagram of a cross section through the body of *Bdellostoma*, just behind the liver.

ntc, notochord. spc, spinal cord. s, somatic branches. ic, "intercostals." d, dermal branches. my, myotomes. Otherwise as previously.

FIGURE XVI.—A ventral view of the dorsal wall of the portal heart of *Bdellostoma dombeyi*, the ventral half having been cut away. (×2.)

ap, anterior portal vein. supr. int, supra-intestinal vein. cp, common portal vein. vv, valves.

FIGURE XVII.—Diagram of the venous system of *Bdellostoma*, dorsal view (approximately natural size). Portal system, green; general system blue. On the right side, the renal branches of the posterior cardinal are omitted. On the left side, the somatic branches are omitted.

acr, acl, right and left anterior cardinals (or jugulars). dcd, scd, deep and superficial branches of anterior cardinals. s, somatic veins. ph, pharyngeal branches. clb, "club-muscle" branches. jv, inferior jugular vein. S, sinus venosus. pnl, pnr, left and right pronephros. pcc, posterior common cardinal. pcr, pcl, right and left posterior cardinals. ha, hp, anterior and posterior hepatic veins. caud, caudal vein. ap, anterior portal vein. cp, common portal vein. gb, gall bladder. sub. int, sub-intestinal vein. gen, genital veins.

FIGURE XVIII.—Diagram of entire circulatory system in *Bdellostoma* lateral view (approximately natural size). Arterial system, red; general venous system, blue; portal system, green.

Lettering same as Figs. XVII and XX.

FIGURE XIX.—Lateral view of the viscera of the pharyngeal and cardiac regions, including ventral view of the right side of the body wall (×1½). In this figure the viscera have been laid over upon the left side, in order to show the relation of the blood vessels to the body wall. As a result, the somatic branches of the anterior portal and dorsal aorta in the branchial region are stretched somewhat beyond their normal length.

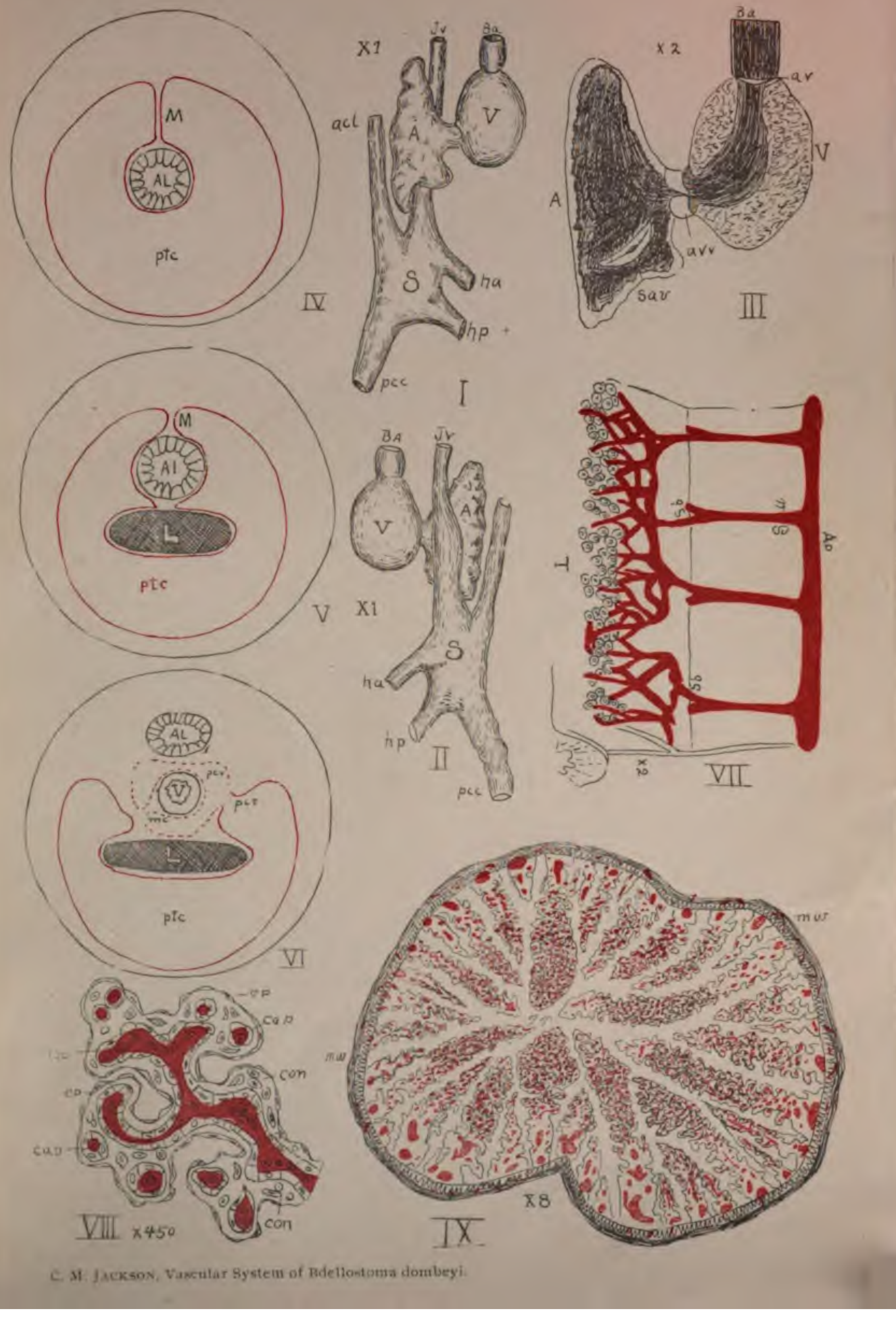
Aa, anterior dorsal aorta. Ap, posterior dorsal aorta. Car, right common carotid. pb, pharyngeal branches. ap, anterior portal vein. ic, intercostals. supr. int, supra-intestinal vein. cv, cystic vein. sub. int, sub-intestinal vein. pcr, right posterior cardinal. ef. br, efferent branchial vessels. clb, "club-muscle" branches.

Otherwise as previously.

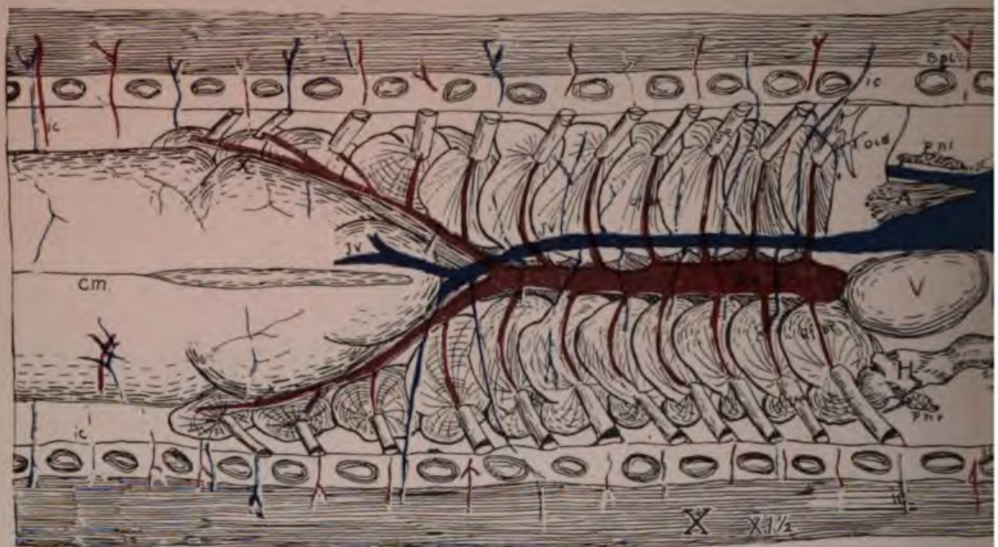
FIGURE XX.—Diagram of the arterial system of *Bdellostoma dombeyi* dorsal view (approximately natural size). The afferent branchial system is omitted. Of the branches of the posterior dorsal aorta, on the right side, the renal branches are omitted. The genital branches should be represented on the right side.

V, vertebralis impar. lbr, lateral branch. ext. car, int. car, external and internal carotid arteries. s, somatic arteries. Car, Cal, right and left common carotid arteries. ef. br, efferent branchials. con. v. connecting vessels. coel, coeliac artery. caud, caudal artery. ren, renal branches. mes, mesenteric arteries.

CONTENTS



C. M. JACKSON, Vascular System of Bdellostoma dombeyi.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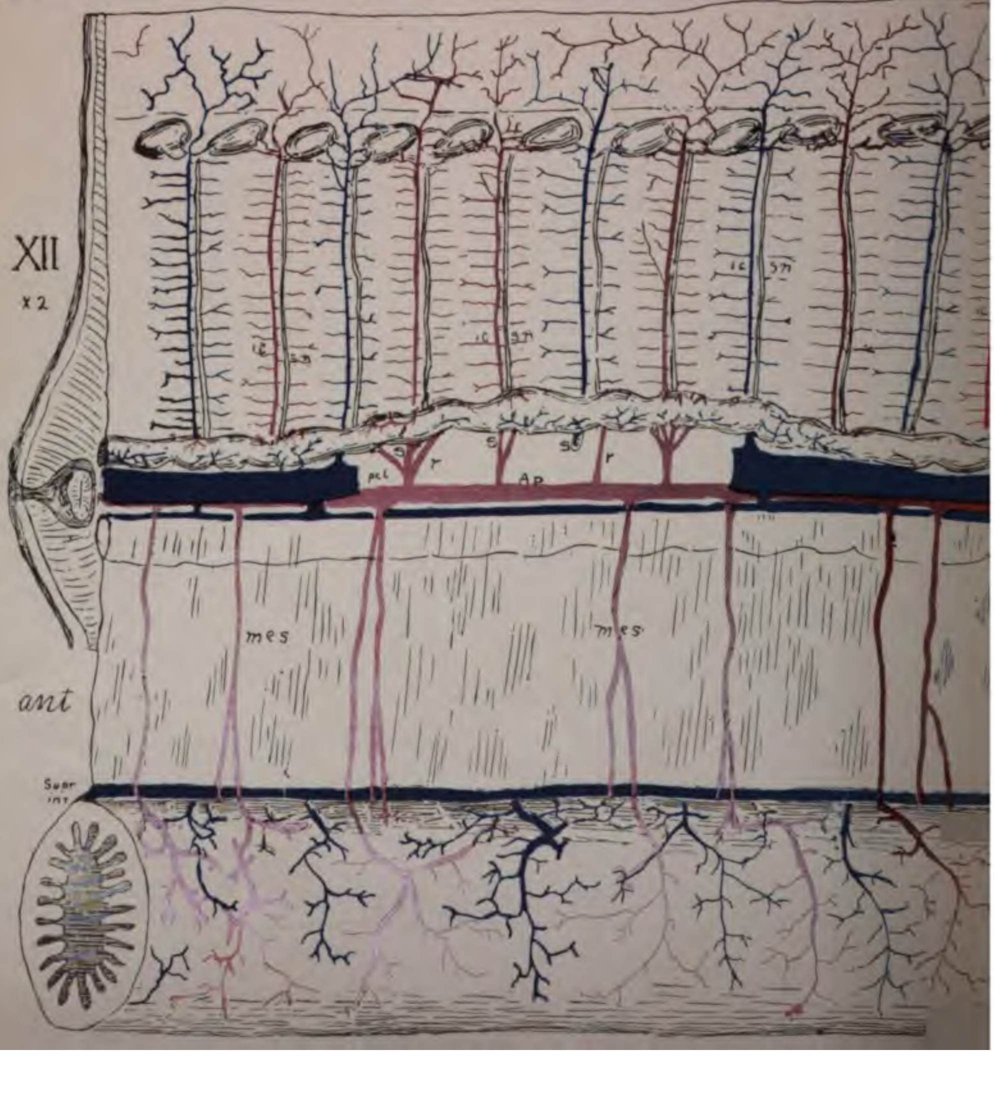
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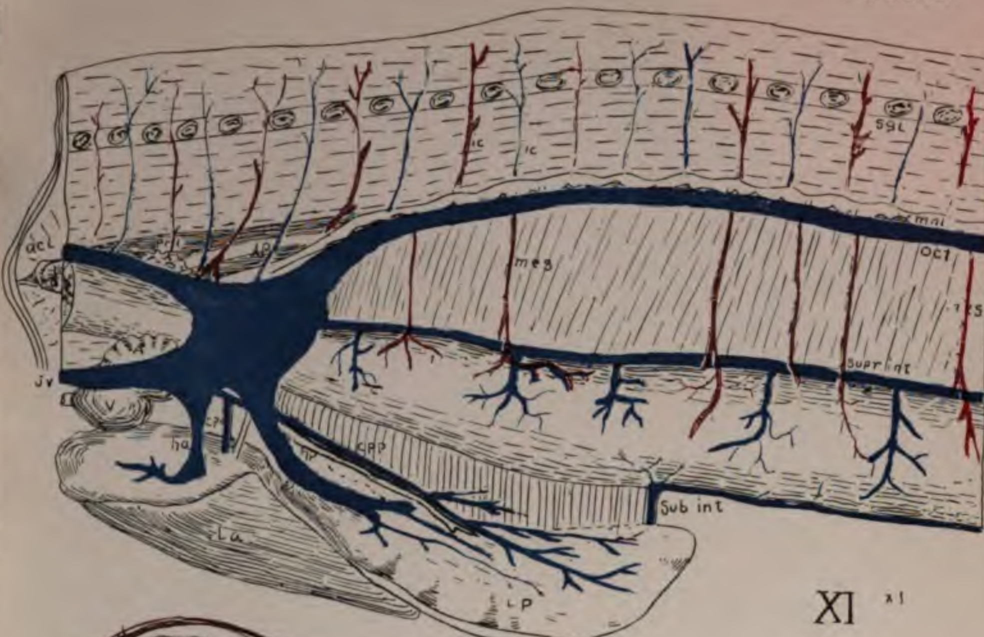

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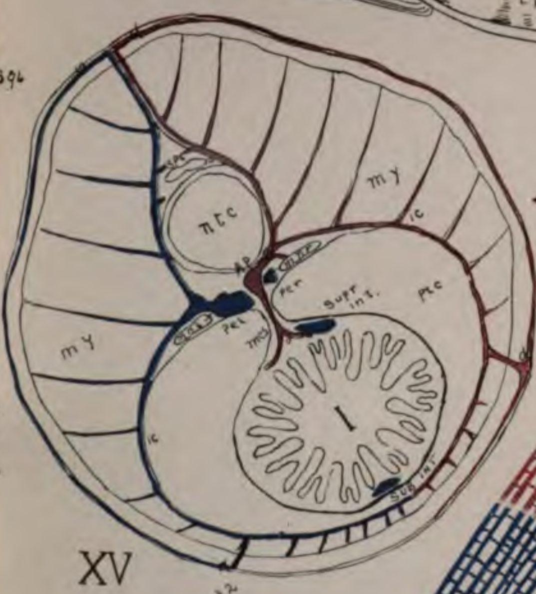

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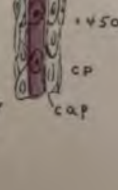

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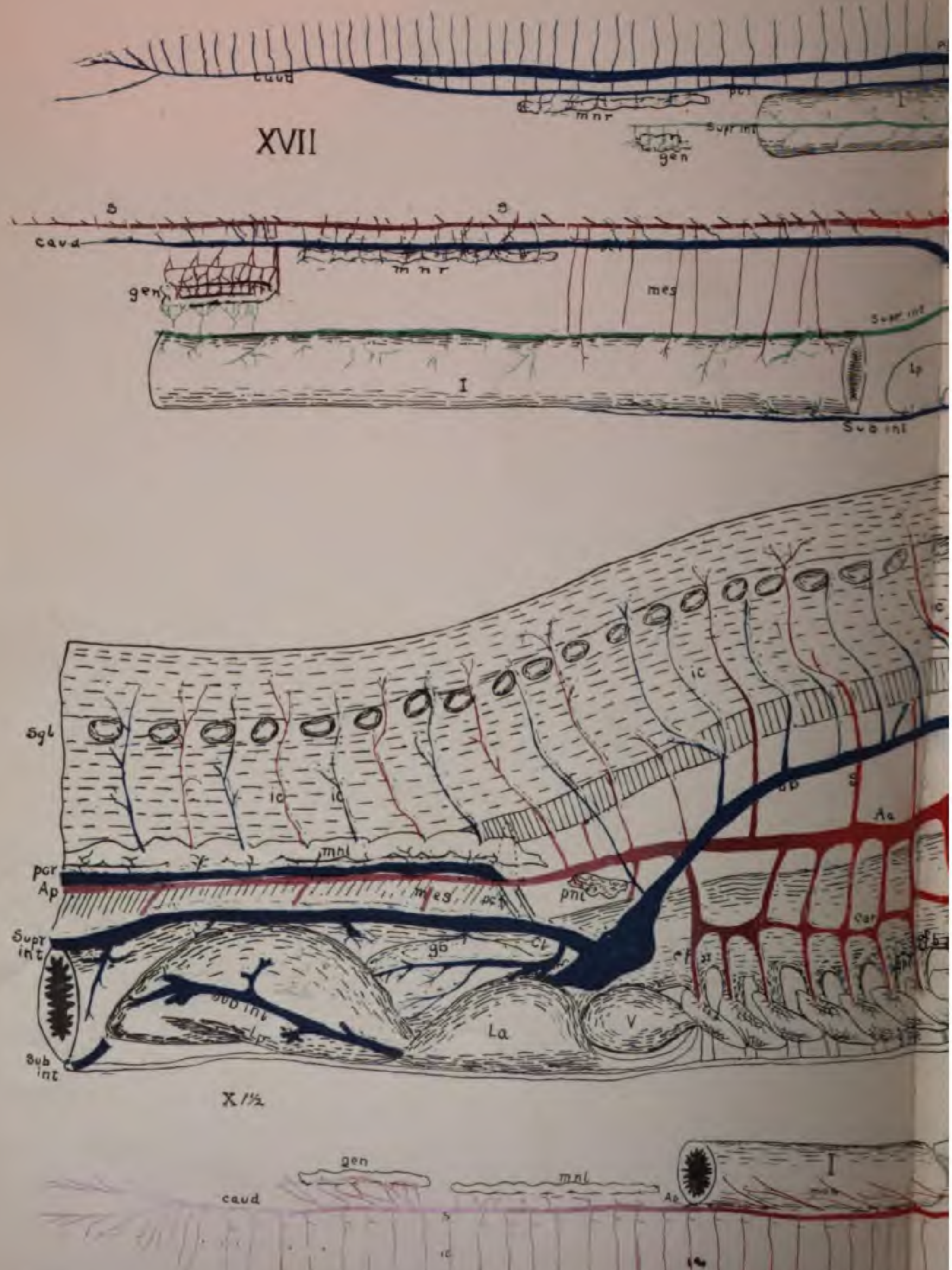

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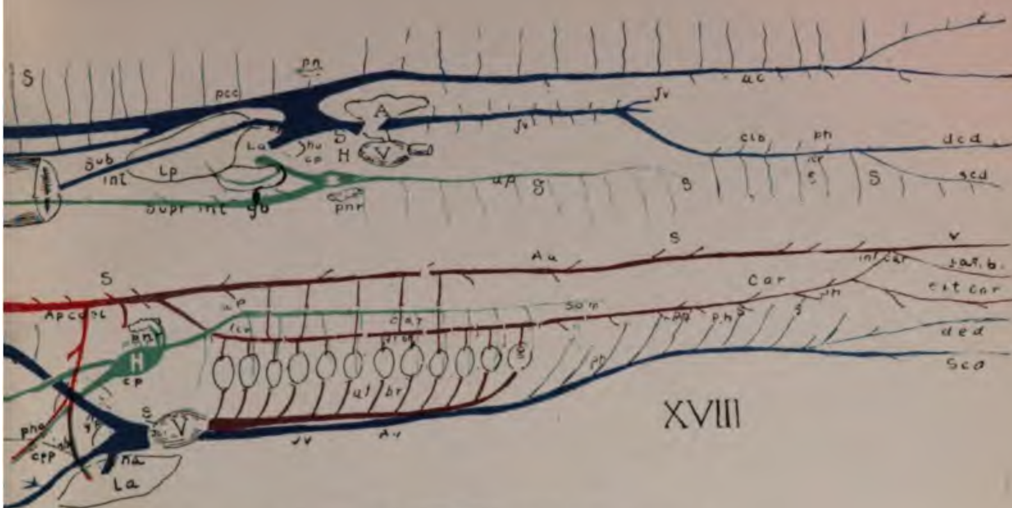

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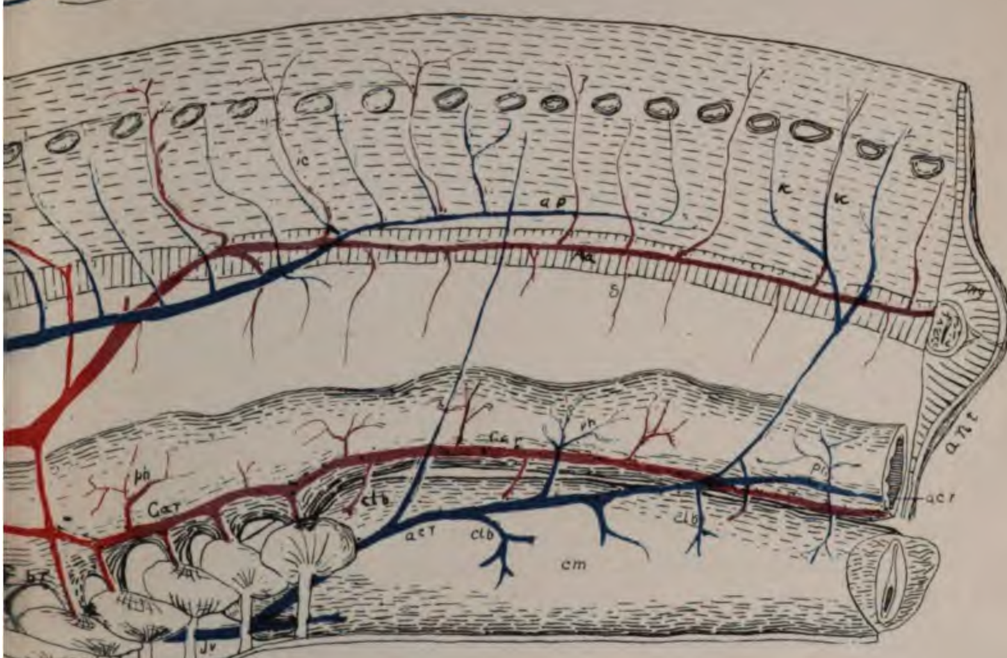

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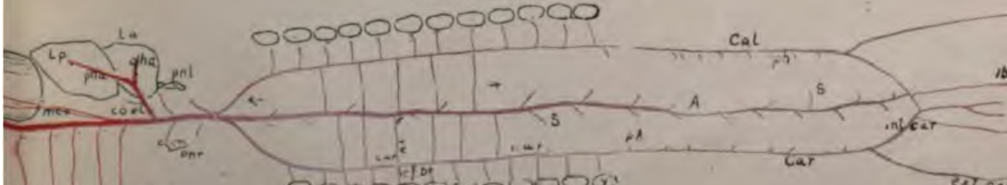

XX

UNIVERSITY OF CINCINNATI

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A Misunderstood Passage

in

Aeschylus.

J. E. HARRY.

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IV.—*A Misunderstood Passage in Aeschylus.*

By Prof. J. E. HARRY,

UNIVERSITY OF CINCINNATI.

The chief purpose of this paper is to prove that the traditional interpretation of *Prometheus* 119 (ὁρᾶτε δεσμώτην με δύσποτμον θεόν) is incorrect. Wecklein[1] remarks: "The imperative has the sense of ὁρᾶν πάρα." Sikes and Willson in their school edition (Macmillan, 1898) tacitly accept Wecklein's interpretation, since on moot points it is their practice to cite the work, if they approve, and to point out the divergencies, if they take issue with the German scholar. In the preface they declare that they have examined this edition "both in the original and in Allen's translation." More, in his version[2] (which bears evidence of a careful comparison of texts and of commentaries), renders "Behold me fettered, the god ill-fated." These citations are sufficient to show that ὁρᾶτε is generally understood to be an imperative, equivalent to ὁρᾶν πάρα;[3] and nowhere have I been able to find a different explanation. Nevertheless, it is not to be inferred that such a conception of the passage is universal, or has even gone unchallenged down to the present day, any more than that ἐραυνᾶτε τὰς γραφάς ὅτι ὑμεῖς δοκεῖτε ἐν αὐταῖς ζωὴν αἰώνιον ἔχειν (John, V. 39) is universally regarded as meaning "Search the Scriptures, for in them ye think ye have eternal life," simply because the Authorized Version translates it so, many (if not most) graduates of theological seminaries from the pulpit preach it so, and the Revised Version fails to state dogmatically that it is not so. The parallel is a good one, since the mistakes are identical in character. A graduate of one of the most renowned seminaries in the country recently took the passage just quoted for his text and exhorted his congregation to read their Bibles more, because this injunction

[1] Allen's translation. [2] Houghton, Mifflin & Co., 1899.

[3] Cf. *Ag.* 1354 ὁρᾶν πάρεστιν, *Cho.* 253 ἰδεῖν πάρεστι, 961 πάρα . . . ἰδεῖν.

was laid upon them by Christ himself. Yet in a book dedicated to Charles II. (written in 1675) by a member of a sect that is generally supposed to have despised learning at that time, I read these words: "Moreover, that place may be taken in the indicative mood, Ye search the scriptures; which interpretation the Greek word will bear, and so Pasor translateth it: which by the reproof following seemeth also to be the more genuine interpretation, as Cyrillus long ago hath observed."[1] But the average student, as well as the layman, is wont to follow tradition, even if he stultifies himself by making a perfectly clear and intelligible passage pointless by his interpretation. That errors are often perpetuated simply because the writer, or teacher, will not think for himself might be shown by numerous examples. In Lysias, I. 18, μύλωνα appears even in the *editio altera aucta et emendata* of the Teubner series (Scheibe). Some of the more ancient writers may have pointed out that the verb in our Aeschylean passage is not imperative, but it is a more difficult matter to prove this for ὁρᾶτε than for ἐραυνᾶτε, since the former makes good sense as commonly interpreted, the latter nonsense.

But it is not sufficient to say that it makes good sense; the critic must ask himself the question: "Is it the Aeschylean sense?"

In the first place, it would never have occurred to me to take ὁρᾶτε as imperative, if my attention had not been called to the matter by the annotators and translators — from the tenor of the passage I do not expect an imperative. From the time Prometheus utters the exclamation ἆ ἆ till he says ὁρᾶτε δεσμώτην με δύσποτμον θεόν his mood, or rather moods, are clearly marked, both by metre and by word: τίς ἀχώ, τίς ὀδμὰ προσέπτα μ' ἀφεγγής (surprise and anticipation) ἵκετο τερμόνιον ἐπὶ πάγον (emotional excitement) πόνων ἐμῶν θεωρός, ἢ τί δὴ θέλων (strong emotion produced by the thought of a possible sympathizing witness — observe the long vowels in which feeling is wont to dwell), and then comes the verse in question, which apprises the unknown visitor of the facts.

[1] *An Apology to the True Christian Divinity*, written in Latin and English, by Robert Barclay (pp. 91 ff.).

In that announcement Prometheus appeals to the strangers' pity: "Whoever you are and whatever your object, ye see in me a god ill-starred in bonds." The succeeding verses are in perfect consonance with this interpretation, and the pathos and beauty of the passage are certainly enhanced by this rendition.

Wecklein has totally misconceived the attitude of Prometheus toward the newcomer. The feeling of anger and indignation finds no lodgement in the sufferer's heart at this moment. *Cadit ira metu.* Nor does Prometheus regard his visitor as "unwelcome." His emotions are wonder and fear. He is nervous. The Oceanids observe this and, accordingly, their first words are words of comfort and encouragement. They desire to allay his fear. The sufferer is bespeaking compassion (cf. 246) of a φιλία τάξις (if haply such the stranger be). He is not indignantly summoning them to gaze upon a god ignominiously treated. The tense of the verb alone indicates that this is the feeling with which Prometheus says ὁρᾶτε. Not until he has been reassured by the kind words of his sympathizers does the Titan's mood change (and in this the poet's representation is psychologically correct), when in tones of mingled plaint and indignation (with the *aorist*) he says δέρχθητ', ἐσίδεσθ' οἵῳ δέσμῳ | προσπορπατὸς τῆσδε φάραγγος | σκοπελοῖς ἐν ἀκροῖς | φρουρὰν ἄζηλον ὀχήσω (141 ff.). Nor does he, when addressing the chorus, ever use any other tense than the aorist (273, 274). Furthermore, Prometheus employs practically the same words (πόνων ἐμῶν ἥκεις ἐπόπτης) when he speaks to his friend and sympathizer, Oceanus (298); but he does not feel that the latter has come τερμόνιον ἐπὶ πάγον to gloat over the torments of the fettered Titan. He has come, it is true, to gaze upon the sufferings of the ill-fated god (cf. θεωρός in 118), but to feel for and with him — θεωρήσων τύχας ἐμὰς ἀφῖξαι καὶ συνασχαλῶν κακοῖς. Then he says δέρκου θέαμα, where both the present and the imperative are in place.

An exact parallel to the verse under discussion is found in 612, where Prometheus makes himself known to Io: πυρὸς βροτοῖς δοτῆρ' ὁρᾷς Προμηθέα. The mood is determined by the number. If the plural had been used, it might well have

been taken as an imperative (cf. 69). Compare Aristophanes, *Lys.* 412 (ὁρᾶτε μέν με δεόμενον σωτηρίας). If ὁρᾶτε is imperative in *Prometheus* 119, it is the only example in Aeschylus, whereas the aorist is frequent: ἴδετε (*Cho.* 406, *Sept.* 111), ἴδεσθε (*Cho.* 973, 980), ἰδοῦ (*Cho.* 231, 247), ἰδέ (*Suppl.* 349 ἰδέ με τὰν ἱκέτιν), ἰδέσθω (*Suppl.* 103), ἰδώμεθα (*Eum.* 142), μήδ' ἴδῃς (*Suppl.* 424 — naturally, by reason of the neg.). So with the optative: ἴδοιμι (*P. V.* 973, *Cho.* 167), ἴδοιτο (*Suppl.* 209), ἴδοισθε (*P. V.* 895). The indicative ὁρᾶτε occurs frequently (*P. V.* 674, *Ag.* 1217, *Cho.* 1034). The singular is found occasionally of intellectual perception (*P. V.* 997 ὅρα νῦν εἴ σοι ταῦτ' ἀρωγὰ φαίνεται, *Eum.* 255 ὅρα ὅρα μαλ' αὖ . . . μὴ λάθῃ, 652 πῶς γὰρ τὸ φεύγειν τοῦδ' ὑπερδικεῖς ὅρα, *Cho.* 924 ὅρα, φύλαξαι μητρὸς ἐγκότους κύνας). The only example of ὅρα in Aeschylus of actual perception is *Eum.* 103 ὅρα δὲ πληγὰς τάσδε καρδίας ὅθεν, but that example speaks volumes for the nature of the present imperative of this verb.[1]

Indeed, the behavior of ὁρᾶν in general, in the imperative (cf. the common ἰδού and φέρ' ἴδω), is similar to that of many verbs in the optative, that is to say, they are used regularly with one tense (present or aorist — the character of the verb determines) unless a special point is to be made by the unusual tense, and it is these shifts, this rarity of usage, that gives the beauty to those particular passages. Some verbs are never found in both tenses. When one wishes for the attainment of an action the aorist is employed. So almost always δοίης, but Sophocles *O.C.* 642 διδοίης. In the beginning of the *Equites* of Aristophanes we read Παφλαγόνα . . . ἀπολέσειαν οἱ θεοί, and *Lys.* 757 κακῶς ἀπόλοιο, 887 ἐξόλοιο, but the present optative of ἀπολλύναι is never found. The same may be said of the simple verb: ὄλοιτο (Eur. *Med.* 83, 659, *Ion* 704, *Phoen.* 350, [*Rhes.*] 720, 875, 906), ὄλοισθε (*Med.* 114), ὀλέσειαν (*Phoen.* 152), ὄλοιο (*Rhes.* 772, Soph. *El.* 292, *Phil.* 1019), but never ὀλλύοιτο. Similarly we find μισοῖεν regularly, but in Euripides, *Or.* 130 μισήσειαν, and

[1] Look! in this place ran Cassius' dagger through:
See, what a rent the envious Casca made:
Through this the well-beloved Brutus stabbed.

in Antiphon, I. 13 δίκη κυβερνήσειεν, where we should expect κυβερνῴη. Likewise γένοιο and γένοιτο are exceedingly common, whereas γίγνοιτο and γίγνοιο are extremely rare. Compare θάνοιμι Eur. *Ion* 763. On the other hand χαίρω is regularly found in the present in the optative. So, too, in the imperative (Ar. *Pax* 338 χαίρετε καὶ βοᾶτε καὶ γελᾶτε).

If ὁρᾶτε in the one hundred and nineteenth verse of the *Prometheus* be imperative, it is not only the sole example in Aeschylus, but also the only instance in the whole range of classical Greek literature, with the exception of a few examples used in a special sense, like the rare optatives just mentioned.

Neither ὅρα nor ὁρᾶτε occurs in Homer, but ἰδέ (ἴδε) is found in θ 443, χ 233, P 179, and ἴδεσθε in Ψ 469. In the lyric poets ὁρᾶτε does not appear. The indicative is found in Solon, IX. 7. In Sophocles the indicative ὁρᾶτε occurs in *Electra* 1228 and *Trach.* 1080 (where πάντες is added and ἰδού, θεᾶσθε precede). The singular ὅρα appears several times, but not in the sense of "behold." In *O.C.* 117, 587, 654, and 1167 ὅρα is used exactly as it is in Demosthenes, *Leptines*, 84 (ὅρα δὴ σκόπει), synonymously with σκόπει. So often in Plato. In *Electra* 925 there is no direct object, and we should expect the present (ἐς κεῖνόν γ' ὅρα), while the examples in 945, 1003, *Phil.* 519 and 833 are all of intellectual perception. But in *Ajax* 351, where Sophocles has occasion to use the imperative, he employs the aorist (ἴδεσθ' μ' οἷον ἄρτι κῦμα φοινίας ὑπὸ ζάλης | ἀμφίδρομον κυκλεῖται).[1]

Euripides has many examples of the aorist imperative, as *Hec.* 808 ἰδοῦ με κἀνάθρησον οἷ' ἔχω κακά, *H.F.* 1029 ἴδεσθε, *I.T.* 1252 κατίδετε ἴδετε τὰν ὀλομέναν γυναῖκα, 1279 ἴδεσθε τὴν πανοῦργον, *Or.* 147 ἴδ' ἀτρεμαῖον ὡς ὑπόφορον | φέρω βοάν. The same may be said of the optative: *Hec.* 1292 ἴδοιμεν, *Cycl.* 437 εἰ γὰρ τήνδ' ἴδοιμεν ἡμέραν, *Med.* 920 ἴδοιμι δ' ὑμᾶς εὐτραφεῖς, *Or.* 798 μήδ' ἴδοιμι μνῆμα. The indicative ὁρᾶτε is frequent: *H.F.* 508 (which is parallel to the Aeschylean passage) ὁρᾶτε μ' ὅσπερ ἦ περίβλεπτος βροτοῖς | ὀνομαστὰ πράσσων, καί μ' ἀφείλεθ' ἡ τύχη | ὥσπερ πτερὸν πρὸς αἰθέρ'

[1] Cf. Ar. *Vesp.* 796 ὁρᾷς ὅσον καὶ τοῦτο δῆτα κερδανεῖς;

ἡμέρᾳ μιᾷ (= ὁρᾶτε ὡς ἐγώ), *I.A.* 1259, 1592, *I.T.* 267, 1065, 1298, *Ion* 1090, *Or.* 273. In *Ion* 1553 we have no difficulty in determining the mood, for the negative settles the question once for all: οὐ γὰρ πολεμίαν με λεύσσετε. Although a synonym of ὁρᾶτε is used, the resemblance to the *Prometheus* passage is striking. In *H.F.* 1072 ὁρᾶτε is used absolutely, like the frequent ὅρα in the *Oedipus Coloneus*. Many examples might be cited from Euripides where the plural (so far as the sense is concerned) might have been taken for an imperative, as *Hec.* 1115 εἰσορᾷς ἃ πάσχομεν; *H.F.* 1117 ὁρᾷς γὰρ αὐτὸς εἰ φρονῶν ἤδη κυρεῖς, *Ion* 1337 ὁρᾷς τόδ' ἄγγος. Examples of ὅρα μή are *Ion* 1523, *Or.* 208, [*Rhes.*] 570. In *Cyclops* 354 ὅρα τάδε and in *Phoen.* 118 εἰσόρα τὸν πρῶτον are found the only present imperatives of this verb (actual perception) in Euripides.

In Aristophanes, *Pax* 327 ff., we have a good illustration of the difference between the two tenses: ἢν ἰδού, καὶ δὴ πέπαυμαι . . . ἀλλ' ὁρᾶτ', οὔπω πέπαυσθε. The remaining indicatives are *Eq.* 67 ὁρᾶτε τὴν Ὕλλαν; *Nub.* 1326, *Pax* 264, ὁρᾶτε τὸν κίνδυνον ὡς μέγας, 891 ὁρᾶτ' ὀπτάνιον ὑμῖν ὡς καλόν. In *Lys.* 837 and *Plut.* 215 the verb is used absolutely. The imperative seems to occur in *Achar.* 1227, but, if the mood is not indicative, it is to be explained as *Pax* 887 βουλή, πρυτάνεις, ὁρᾶτε τὴν Θεωρίαν, where the present is peculiarly appropriate. Moreover, for metrical reasons alone we should expect to find ὅρα and ὁρᾶτε in a writer like Aristophanes more frequently than ἰδέ and ἴδετε (ἰδοῦ and ἴδεσθε, used by Homer and Aeschylus, being excluded by the exigencies of the style), whereas the present imperative in prose, as we shall see, is used but once, and there for a special reason. The examples of ὅρα in Aristophanes are *Vesp.* 799 ὅρα τὸ χρῆμα (= *eccere, just think*), 1493 κατὰ σαυτὸν ὅρα, *Av.* 651 ὅρα ὡς, *Eccl.* 300 ὅρα ὅπως.

So much for the poets. Of the prose writers Herodotus and Thucydides furnish very few examples of either ὅρα or ὁρᾶτε. All[1] are indicative (ὁρᾶτε *Hdt.* III. 137, IV. 139[2];

[1] Actual perception.

[2] If the verb were plural in VII. 5 (ὁρᾷς τὰ ὑπερέχοντα ζῷα ὡς κεραυνοῖ ὁ θεὸς) the tendency would doubtless be to consider the mood imperative.

ὅρα ὅκως III. 36; ὅρα νυν (*consider now*) III. 134; ὁρᾶτε Thuc. I. 68, 3, V. 87; ὁρᾶτε ὅπως μή III. 57, 1; ὅτῳ τρόπῳ VI. 33, 3).

When we come to the philosophers we have a different tale to tell. In Plato examples of ὅρα and ὁρᾶτε are particularly abundant. The prettiest illustration in all his works — indeed, in all Greek works — of the distinction made in the use of the tenses of this verb in the imperative mood is afforded by a passage in the *Republic* (514 A and B). It is in the famous allegory of the cave: ἰδὲ γὰρ ἀνθρώπους οἷον ἐν καταγείῳ οἰκήσει σπηλαιώδει . . . μεταξὺ δὲ τοῦ πυρὸς καὶ τῶν δεσμωτῶν ἐπάνω ὁδόν, παρ' ἣν ἰδὲ τειχίον παρῳκοδομημένον. . . . Ὅρα τοίνυν παρὰ τοῦτο τὸ τειχίον φέροντας ἀνθρώπους σκεύη τε παντοδαπὰ ὑπερέχοντα τοῦ τειχίου καὶ ἀνδριάντας. The speaker bids his friend visualize the scene; but the first object to which he directs his attention is a fixed group, the second a fixed wall (hence ἰδέ in both instances), but the third consists of a succession of figures (ἀνθρώπους φέροντας σκεύη, hence the present ὅρα). The aorist occurs also in 434 A, *Alcib.* 132 E ἰδὲ σαυτόν, *Phaedo* 72 A. So the first person ἴδω *Rep.* 457 C, ἴδωμεν 603 C, *Leg.* 976 C, *Charm.* 172 C, *Gorg.* 455 A. An excellent example of ὅρα (as distinguished from ἰδέ of mental perception) is *Rep.* 432 C ὅρα οὖν καὶ προθυμοῦ κατιδεῖν. In the first verb the effort is expressed by the tense; in the second by the verb itself (προθυμοῦ), and so the aorist of the first verb is employed as a complement. This use of ὅρα is naturally frequent in Plato: *Rep.* 358 D, 416 D, 613 E, *Alcib.* 115 C (ὅρα εἰ), 121 B, II *Alcib.* 139 D (ὅρα μή), *Rep.* 596 A (ἀλλ' αὐτὸς ὅρα), *Alcib.* 117 C (ὅρα καὶ σὺ κοινῇ), 104 C, II *Alcib.* 145 A, *Rep.* 596 B, *Laches* 188 C (τόνδε ὅρα ὅπως ἔχει). Likewise the dual, *Euthydemus* 274 A (ἀλλ' ὁρᾶτον, ὦ Εὐθύδημέ τε καὶ Διονυσόδωρα, εἰ ἀληθῆ ἐλέγετον), and the plural, *Symposium* 192 E ὁρᾶτε εἰ τούτου ἐρᾶτε, *Laches* 187 D, *Rep.* 642 A.

One might be inclined to think that the reason why ὁρᾶτε is so rare is that the occasions for using the word in this form are comparatively unfrequent, whereas the singular ὅρα would be much commoner. In Xenophon, however, ὅρα occurs only twice: *Cyropaedia* III. 1, 27 ὅρα μή (bis) and ὅρα

εἰ V. 4, 33. The plural, on the other hand, is abundant: *Cyrop.* II. 1, 18 (ὁρᾶτε τὰ ὅπλα), III. 2, 12 (νῦν δὲ ὁρᾶτε δὴ ἐν οἵῳ ἐστέ), V. 1, 10 (αὐτοὶ ὁρᾶτε), IV. 1, 15 (ὁρᾶτε μή), IV. 2, 26 (ὁρᾶτε ὅπως), IV. 5, 3 (αὐτοὶ ὁρᾶτε), IV. 5, 44; IV. 5, 46; VII. 1, 22; VII. 5, 43; *Symposium* VIII. 3; *Anab.* I. 3, 16; III. 2, 4; III. 2, 29; III. 5, 5; IV. 6, 7; V. 2, 10 (τάδε ὁρᾶτε· εἰ μὲν κτέ); V. 6, 21; V. 6, 28; VI, 5, 16 (ὁρᾶτε πότερον). All of these are indicative except those followed by μή, ὅπως, εἰ, and πότερον.

In the orators there is not a single example of ὁρᾶτε imperative. Lysias has eight of the indicative (XVI. 12, XIX. 2, XX. 3, XXI. 13, XXIV. 14, XXV. 34, XXXI. 12, *Fr.* 70) and two of the subjunctive ὁρᾶτε (XXVIII. 2, XXX. 33), but none of the singular ὅρα. The plural occurs but twice in Isaeus (IV. 15 and V. 39), and both are indicative. Demosthenes has seven examples of ὅρα and twelve of ὁρᾶτε (intellectual perception). The indicative of actual perception occurs XXI. 189, XLV. 70, and of mental perception XXIII. 106. As a synonym of σκόπει, ὅρα is often found in Demosthenes, *e.g.*, ὅρα δ' οὑτωσί (XX. 21), ὅρα δὴ καὶ σκόπει (XX. 84). The latter (σκόπει) is almost as peculiar in its behavior as παῦε and παῦσαι, almost as regular as ἴδετε and ὁρᾶτε, that is to say, the singular imperative is usually present, whereas the plural is, as a rule, in the aorist; σκοπεῖτε is rare, but σκέψασθε exceedingly common (Thuc. III. 47, 1; 57, 5; 57, 7; Ar. *Pax* 888; Isae. IV. 9, IX. 4, 30, 36; Xen. *An.* III. 2, 20), whereas σκόπει is the regular form for the singular, σκέψαι unusual (Ar. *Thesm.* 160, 1114; *Eccl.* 124).[1] Compare Plato II. *Alcib.* 143 E ἐπισκεψώμεθα. In like manner ὁρῶμεν instead of ἴδωμεν is very rare, but occasionally it is necessary; for, if one says ὅρα μή, he would also naturally say ὁρῶμεν μή (Plato, *Laches* 196 C), but the optative never, except, of course, in dependent sentences, like Xenophon, *An.* III. 3, 2 (εἰ οὖν ὁρῴην ὑμᾶς κτέ).[2]

[1] In [Dem.] XLVI. 16 f. σκέψασθε . . . σκοπεῖτε . . . μὴ σκέψησθε.

[2] After examining a large number of translations and editions in many languages, if haply I might find a single departure from the traditional interpretation of the passage under discussion, I discover that Hartung (Leipzig, 1852) renders: "Ihr seht in Banden einen unglücksel'gen Gott."